City of Kyle, Texas

Water Distribution System Hydraulic Model Final Report

Burgess & Niple, Inc.

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Executive Summary

Burgess & Niple, Inc. (B&N) was engaged by the City of Kyle to develop a hydraulic model of the water distribution system. The purpose of this report is to present the hydraulic model building methodology and process employed for developing the hydraulic water model and resultant recommendations for the City of Kyle.

Hydraulic Model Evaluation

The performance of Kyle's system under existing and future demand conditions is evaluated using the calibrated water model. The hydraulic model contains all the pipes, valves, hydrants, tanks, and pumps within the potable water system. The model is used to identify hydraulic, supply, and storage deficiencies in the water system.

Hydraulic Modeling Software

WaterGEMS®, developed by Bentley Systems, was the software selected to perform the modeling. WaterGEMS® works in conjunction with AutoCAD, Microstation, ArcGIS, or as a stand-alone program in Microsoft Windows. The model can be run as a steady-state (SS) simulation, or as an extended period simulation (EPS). SS simulations produce results based on one initial set of conditions (i.e., number of pumps running, tank elevations, etc.). EPSs produce results based on changing conditions (i.e., tanks filling or draining, pumps turning off or on, etc.) over a specified time interval. The EPS represents a "real-life" analysis of the system by analyzing the model dynamically.

Model Construction in WaterGEMS®

All pipe lines and facilities included in the hydraulic model were obtained from the GIS information provided by the City of Kyle and checked for accuracy. The distribution system network consists of approximately 899 fire hydrants and approximately 2,717 valves. Customer meter demands applied contain user water consumptions. Elevations for the model are derived from contour data (two foot intervals) provided by the City. Using the contour data, ground elevations are extracted and assigned to all junctions and facilities in the model. Field mapping using GPS with mapping grade accuracy was used to verify pump station and tank base elevations in the field.

Model Calibration

The hydraulic model with the existing system configuration and demands is calibrated to improve the accuracy of the model results and provide a planning tool that can be used to identify system deficiencies and recommend improvements and address system deficiencies. Model calibration is the process of comparing model results with field results. The hydraulic model is calibrated for two scenarios; 1) Steady State Calibration: Simulating fire hydrant flow tests to match field results; 2) 24-hour Extended Period Simulation (EPS) Calibration.

Population, Water Demands and Water Supply

Based on 2013 data from the United States Census Bureau, Kyle currently serves a population of approximately 31,760 and the population within Kyle is expected to be approximately 78,357 by the year 2035, representing a yearly growth rate of 4.2 percent. This population growth results in increased water demands and water supply requirements. Below is a summary of 2013 demands:

- Average daily demand is 1,715 gallons per minute (gpm)
- Maximum daily demand is 2,693 gpm
- Peak hour demand is 5,145 gpm

The 2013 average daily demand is 1,715 gpm. By estimating a per capita water use of 64 gallons per capita per day and using 18-percent water loss, the average daily demand in the Year 2035 is expected to be 4,090 gpm with the projected population of 78,357. Below is a summary of projected 2035 demands:

- Average daily demand is 4,090 gpm
- Maximum daily demand is 6,405 gpm
- Peak hour demand is 12,270 gpm

Kyle's existing supply sources consist of groundwater and surface water. There is sufficient redundancy in the facilities delivering these supplies to meet existing demands; while additional supplies are necessary for future demands.

Recommended Improvements

Recommendations are divided into three categories; 1) Priority 1 improvements and 2) Priority 2 improvements 3) Priority 3 improvements.

The improvement projects are divided into the following categories:

- Pipeline improvements for pressure deficiencies (P)
- Pipeline improvements to address fire flow deficiencies (FF)
- Pipeline improvements to address headloss and velocity deficiencies (HV)
- Pipeline added to serve future subdivisions (FS)
- Pipeline added for Pump Supply (PPS)
- Pump Supply (PS)
- Pump Replacement (PR)
- Small diameter pipeline replacement for pipelines with a diameter smaller than 6 inches (SD)
- Storage Improvements (S)

Table ES.1: Summary of Priority 1 Water System Improvements			
Category	Improvements Description	Quantity	Unit
FF	Pipeline Improvements for fire flow deficiencies	0.4	miles
HV	Pipeline Improvements for headloss and velocity deficiencies	1.8	miles
FS	Pipeline addition for future subdivisions	5.7	miles
S	Storage Improvements	2.11	MG
PPS	Pipeline added for Pump Supply	1.2	miles
PS	Pump Supply from High Pressure Zone to Potential Third Pressure Zone	1,700	gpm
PR	Pump Replacement	5	Each

Table ES.2: Summary of Priority 2 Water System Improvements			
Category	Improvements Description	Quantity	Unit
P	Pipeline Improvements for pressure deficiencies	0.4	miles
S	Storage Improvements	1.15	MG
PS	Pump Supply to Existing System	500	gpm
PR	Pump Replacement	7	Each

Table ES.3: Summary of Priority 3 Water System Improvements			
Category	Improvements Description	Quantity	Unit
SD	Pipeline with a diameter less than 6-inches	9.5	miles

Cost Estimates for All Water System Improvements

Presented costs are calculated using 2015 dollars. The total costs values include a contingency of 30 percent for engineering cost and construction.

Table ES.4: Summary of All Water System Improvement Costs	
Facility Type	2015 ($ Million)
Priority 1 Water System Improvements	
Pipeline Improvements for Deficiencies	2.3
Pipeline Addition for Future Subdivisions	7.0
Pipeline Addition for Pump Supply	1.7
Pump Replacement	0.1
Pump Supply from High Pressure Zone to Potential Third Pressure Zone	1.1
Storage	7.1
Subtotal	**19**
Priority 2 Water System Improvements	
Pipeline Improvements for Deficiencies	0.4
Pump Replacement	0.1
Pump Supply to Existing System	0.3
Storage	3.9
Subtotal	**4.7**
Priority 3 Water System Improvements	
SD Pipeline Improvements	6.3
Subtotal	**6.3**
Total	**30.5**

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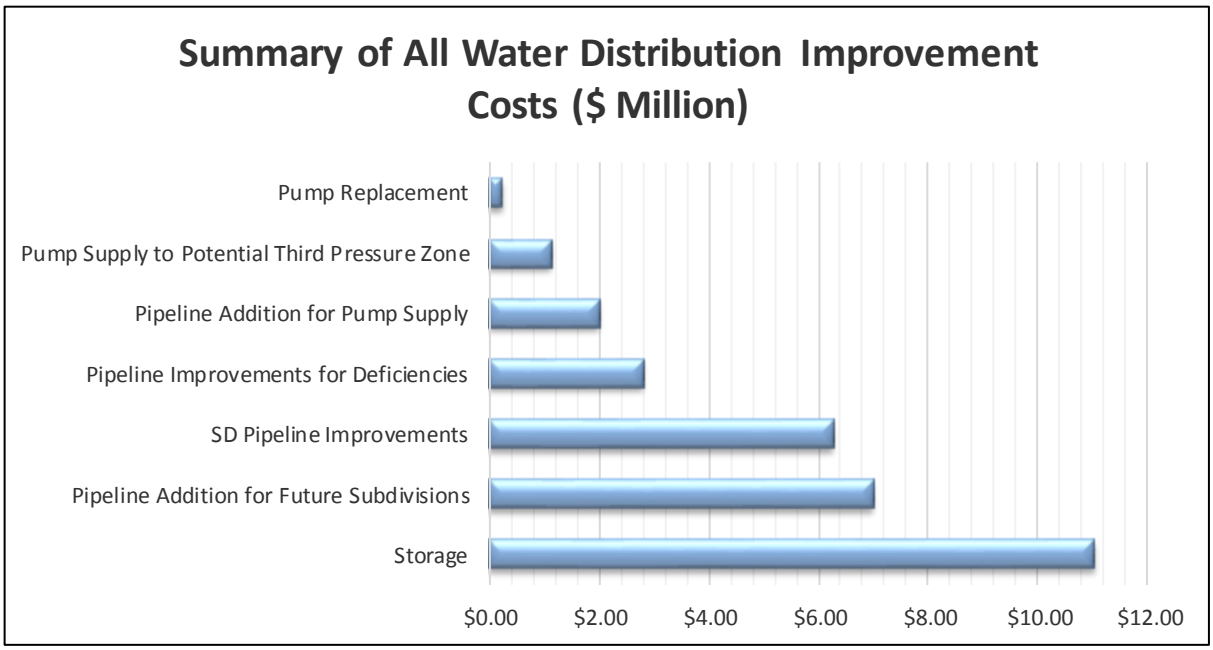
Figure 7.1.1 – Summary of All Water Distribution Improvement Costs



Section 1.0 Introduction

Burgess & Niple, Inc. (B&N) was engaged by the City of Kyle to develop a hydraulic model of the water distribution system. The purpose of this report is to present the hydraulic model building methodology and process employed for developing the hydraulic water model and resultant recommendations for the City of Kyle.

1.1 Hydraulic Modeling Software

WaterGEMS®, developed by Bentley Systems, was the software selected to perform the modeling. WaterGEMS® works in conjunction with AutoCAD, Microstation, ArcGIS, or as a stand-alone program in Microsoft Windows. The model can be run as a steady-state (SS) simulation, or as an extended period simulation (EPS). SS simulations produce results based on one initial set of conditions (i.e., number of pumps running, tank elevations, etc.). EPSs produce results based on changing conditions (i.e., tanks filling or draining, pumps turning off or on, etc.) over a specified time interval. The EPS represents a “real-life” analysis of the system by analyzing the model dynamically.

1.2 Modeling Tasks

The tasks performed for the water distribution modeling includes:

- Create a calibrated steady state and extended period model
- Project Potable Water Demands in the service area for the next 20 years
- Conduct Pressure Zone Evaluation
- Analyze the Potable Water Distribution System under Existing Conditions
- Analyze the Potable Water Distribution System under Future Conditions
- Prepare a Capital Improvement Program for the Potable Water System
- Provide Training to Kyle Staff to use the Hydraulic Model

1.3 Data Sources

Kyle staff supplied reports, maps (GIS), Supervisory Control and Data Acquisition (SCADA) data, pump curves, and record drawings of existing water distribution infrastructure. In addition, meetings with City staff were held to obtain operation and maintenance information on the system.

1.4 Abbreviations

AC	Asbestos Cement
AF	Acre-Feet
ADD	Average Day Demand
AWWA	American Water Works Association
EPS	Extended Period Simulation
ft	Feet

FF	Fire Flow
GIS	Geographic Information System
gpd	Gallons Per Day
gpcd	Gallons Per Capita Per Day
gpm	Gallons Per Minute
HGL	Hydraulic Grade Line
ISO	Insurance Service Office
In	Inch or Inches
MDD	Maximum Day Demand
MG	Million Gallons
mgd	Million Gallons Per Day
MinDD	Minimum Day Demand
/	Per
PHD	Peak Hour Demand
PRV	Pressure Reducing Valve
psi	Pounds Per Square Inch
PVC	Polyvinyl Chloride
SCADA	Supervisory Control and Data Acquisition
SD	Small Diameter
SOW	Scope of Work
SS	Steady-State Simulation

Section 2.0 Existing Potable Water System

2.1 System Description

Pressure Zones
The Kyle Water Distribution System consists of two pressure zones, the low pressure zone at an overflow elevation of 850 feet and the high pressure zone at an elevation of 930 feet.

Facilities
Existing City of Kyle Water Distribution facilities are listed in Table 2.1.1 below:

Table 2.1.1: Summary of Facilities

Facility Type	Number
Booster Pump Stations	5
Groundwater Wells	5
Emergency Connection	1
Surface Water Connection	2
Pipeline (miles)	133
Hydrants	899
Valves	2,717
Customer Meters (as of 2013)	8,267

Water Supply
Kyle receives water from groundwater and surface water resources.

The following is a list of current City of Kyle groundwater resources:

- Well 1 and 5 – Edwards Aquifer
- Well 2 – Edwards Aquifer
- Well 3 – Edwards Aquifer
- Well 4 – Barton Springs

The Kyle surface water resources include Guadalupe-Blanco River Authority (GBRA) supplied treated water at Lehman Station and at Yarrington Station.

There is also an emergency source of a combination surface and groundwater supplied from the City of San Marcos at the Yarrington Station.

Water Treatment
The following pump stations contain chemical addition:

- Well 3 – chlorine and fluoride
- Rebel Road – chlorine (injection at each well)
- Yarrington – chlorine
- Well 4 – chlorine

Tanks

City of Kyle water distribution system tanks are listed in **Table 2.1.2**:

Table 2.1.2: Summary of Tanks				
Name	Type	Capacity (gal)	Level Range (ft)	HGL Range (ft)
1626 Well 4	Ground Storage	500,000	44.0	734.24 – 778.24
Dacy Tower	Elevated	300,000	29.5	812.12 – 841.70
North Old Stagecoach Road	Ground Storage	500,000	48.0	803.00 – 851.00
North Old Stagecoach Road	Elevated	150,000	28.0	903.00 – 931.00
North Old Stagecoach Road	Standpipe	41,000	48.0	803.00 – 851.00
Lehman	Ground Storage	500,000	44.0	699.96 – 743.93
Plum Creek	Standpipe	200,000	100.0	898.40 – 928.40
Post Oak	Elevated	750,000	40.0	810.00 – 850.00
Roland Lane	Elevated	300,000	30.3	830.70 – 849.30
Rebel Road GST #1	Ground Storage	150,000	23.3	755.44 – 778.74
Rebel Road GST #2	Ground Storage	150,000	23.3	755.67 – 778.97
Well 4 Kohler's Crossing	Elevated	500,000	37.2	910.40 – 930.40
Yarrington	Ground Storage	500,000	31.0	672.49 – 703.49
Yarrington	Ground Storage	250,000	31.0	672.49 – 703.49

Pumps

The City of Kyle water distribution system booster stations are presented in **Table 2.1.3**:

Table 2.1.3: Summary of Pumps		
Name	Number of pumps	Design Point (gpm @ TDH)
1626	2	750 @ 191
Lehman	2	750 @ 191
Rebel Road Service	3	750 @ 140
Yarrington	3	550 @ 255
Well 1	1	650 @ 480
Well 2	1	550 @ 375
Well 3	1	425 @ 460
Well 3 Control Room	2	500 @ 100
Well 3 Outside	2	1,000 @ 100
Well 4	1	470 @ 126
Well 5	1	650 @ 480

Pressure Reducing Valve

Within the City of Kyle water distribution system there is one 8-inch pressure reducing valve (PRV) located approximately 100-feet north of the intersection of Physicians Ways and Marketplace Avenue. The downstream pressure is set at 50 psi. The valve is configured top open at 40 psi and closes at 50 psi.

Distribution System Network

The system consists of approximately 130 miles of pipes in the water distribution system ranging from 1- to 16-inches in diameter. The distribution of pipeline diameters is summarized in **Table 2.1.4**.

Table 2.1.4: Summary of Pipeline Length

Diameter (inches)	Length (feet)	Length (miles)	Percentage of total Length (%)
Less than 1.5	3,970	0.75	0.58
2	31,255	5.92	4.56
3	6,494	1.23	0.95
4	19,917	3.77	2.91
6	73,086	13.84	10.67
8	335,727	63.58	49.02
10	58	0.01	0.01
12	184,352	34.92	26.92
14	0	0.00	0.00
16	30,030	5.69	4.38

Table 2.1.5 summarizes the total lengths of pipes in the water distribution system by material type. Approximately 34 percent of the pipelines have an unknown pipe material. The most common pipe material is polyvinyl chloride (PVC).

Table 2.1.5: Summary of Pipeline Material

Material	Length (feet)	Length (miles)	Percentage of total Length (%)
Asbestos Cement (AC)	20,198	3.83	2.95
Copper	694	0.13	0.10
Ductile Iron (DI)	1,238	0.23	0.18
Polyethylene (PE)	295	0.06	0.04
Polyvinyl Chloride (PVC)	422,513	80.02	61.69
Steel	149	0.02	0.02
Unknown	235,284	44.50	34.35

A summary of pipe for each designated installation period is shown in **Table 2.1.6**. Approximately 27 percent of pipelines have an unknown installation date, while approximately 49 percent of pipelines were installed between the years 2000 and 2009.

Table 2.1.6: Summary of Pipeline Installation Period			
Installation Period	Length (feet)	Length (miles)	Percentage of total Length (%)
1970-1979	10,740	2.03	1.57
1980-1989	18,814	3.56	2.75
1990-1999	84,326	15.97	12.31
2000-2009	334,681	63.39	48.87
2010-2014	48,934	9.27	7.14
Unknown	184,216	34.89	26.90

Data Collection

Data used for the development of the hydraulic water model is obtained from a variety of sources. Key information includes:

- GIS database of all water mains and water facilities
- Hydraulic water system schematic
- Pump curves
- Pump controls
- Water production records (2013)
- Customer usage records (2013)
- Supervisory Control and Data Acquisition (SCADA) data
- Ground elevation two-foot contour lines
- GPS elevations
- Aerial photography coverage
- Imported and emergency water connection, sizes, and capacity
- Summary of projects currently under construction or scheduled for construction in near future
- Water Model RFQ

Model Construction

All pipe lines and facilities included in the hydraulic model are obtained from the GIS information provided by the City of Kyle. The spatial representation of the hydraulic model in NAD 1983 State Plane Texas South Central FIPS 4204 (US Feet) is consistent with the coordinate system in with the Kyle's GIS data is projected.

Pipelines

All pipelines and facilities in the model are checked for accuracy and some pipe lines and facilities are redrawn to resolve model connectivity issues. Model attributes for pipelines include the pipe number, length, diameter, material, roughness, and pressure zone. The Object ID is maintained in the pipe GIS properties.

Fire Hydrants
The distribution system network consists of approximately 899 fire hydrants. The Object ID is maintained in the hydrant GIS properties.

Valves
The distribution system network consists of approximately 2,717 valves. The Object ID is maintained in the valve GIS properties. A summary of system valve types is displayed in **Table 2.1.7**.

Table 2.1.7: Summary of Valves

Type	Total Number of Valves
Gate	2,644
Air Vacuum	62
Control	7
Check	1
Back Flow Preventer	3

Junctions
Junctions are defined as the intersections of two or more pipelines, or at the location where any pipeline changes diameter or material. Attribute information for junctions include elevation and water loss (unaccounted for water) demand.

Customer Meters
Customer meter demand data includes user water consumptions. Attribute information for customer meters include demand (gpm), billing address, and account number.

Facility Elevation Data
Elevations for the model are derived from contour data (two foot intervals) provided by the City. Using the contour data, ground elevations are extracted and assigned to all junctions and facilities in the model. Field mapping using GPS with mapping grade accuracy was used to verify pump station and tank base elevations.

Section 3.0 Population and Water Demands

3.1 Water Production

The water production for each groundwater and surface water source for a period of October 2013 to September 2014 pump reports obtained from the City was used to estimate the total average daily demand. Based on this information, **Table 3.1.1** shows the average pump production (gpd) for each source.

Table 3.1.1: Average Pump Production for Groundwater and Surface Water Supply Sources

Well 1 (gpd)	Well 2 (gpd)	Well 3 (gpd)	Well 4 (gpd)	Well 5 (gpd)	San Marcos (gpd)	GBRA Lehman (gpd)	GBRA Yarrington (gpd)	Total (gpd)	Total (gpm)
72,426	75,923	44,202	605,518	294,083	1,095	825,170	549,137	2,467,554	1,715

3.2 Demands

Average day demand (ADD) is a baseline for computing peaking factors. The maximum day demand (MDD) peaking factor and peak hour demand (PHD) factors are used to scale up the ADD to estimate MDD and PHD. These estimated MDD and PHD are the demand conditions used to size water distribution system pipelines and facilities.

Maximum Daily Demands
October 2013 to September 2014 pump production data is used to calculate the peaking factor for MDD. The maximum daily and average daily pump production for all the pumps during this period is 4.024 MGD and 2.570 MGD. From this, a MDD peaking factor of 1.57 is used, resulting in a MDD of 2,693 gpm.

According to the American Water Works Association (AWWA) publication M32, Distribution Network Analysis for Water Utilities, the ratio of maximum day demand to average day demand has been observed to vary from 1.2 to 2.5. The distribution system's MDD ratio falls within this range.

Peak Hour Demand
The peak hour demand multiplier of 3 is used based on an assumption typically used for most cities of this size. According to AWWA publication M32, the ratio of peak-hour demand to maximum-day demand varies from 1.3 to 2.0. The ratio of 1.91 falls into this range, resulting in a PHD of 5,145 gpm.

Largest Users
A list of the top ten water consumption users based on the calendar year 2013 billing report in presented in **Table 3.2.1** on the following page.

Table 3.2.1: 2013 Top Ten Water Consumption Users		
Name	Service Address	Year 2013 Average Water Demand (gpm)
Kyle Correctional Center	23001 N IH 35	56
Seton Medical Center - Hays	6001 Seton Parkway #2	31
Vista at Plum Creek	4925 Cromwell	20
Aztec Village/Oakhill Community	291 Roland Lane	18
Bluebonnet Estates	Dacy Lane	13
Saddle Creek Apartments	21393 IH 35-Apt	11
Legend Oaks Healthcare and Rehab	1640 Fairway-Nursing Center	10
Tristar Utilities	FH Mtr No. 59858792	7
Vista at Plum Creek	4925 Cromwell	7
HCISD-Lehman High school	1700 Lehman Road	6

Customer Demands

The water demands for existing conditions are based on customer usage information (billing data) provided by Kyle. The billing data covers the water usage for nearly 8,270 accounts for the period of September 2011 to August 2014. The data includes information on service IDs, street addresses, and monthly consumption. The average daily demand used in the model is based on the year 2013, the most current twelve month cycle of customer usage data available (data collected October 2014). Based on year 2013 data, the average water consumption for the entire water system is 1,405 gpm (2.02 MGD). **Table 3.2.2** contains a comparison of the consumption and production data in the system.

Table 3.2.2: Summary of Water Loss				
Year	Produced Water (gpm)	Billed Consumption (gpm)	Water Losses (gpm)	Water Losses (% of production)
2013	1,715	1,405	310	18

Unaccounted for Water

The difference in volumes between water produced and water consumed is defined as "unaccounted-for water", or the water losses within a system. Unaccounted-for water may be attributed to accounting and metering errors, leaking pipes, unmetered water use, water theft or any other event causing water to be unmeasured, such as leakage, hydrant flushing and fire-fighting. As shown in **Table 3.2.2**, the calculated water loss for 2013 is 18-percent.

Geocoding

The process of geographically locating each billing record is known as geocoding. Each billing record is geographically located using the street addresses in the billing data and street centerline GIS coverage. The geocoding process electronically places the location of each service connection on a map. The total water loss is equally distributed among junctions across the entire system as a separate demand.

Future demands are allocated geographically based on the location of the vacant parcels in the existing land use GIS coverage. The total demand for each parcel is calculated based on the size of the parcel. Once the future demands are determined, the demands are assigned to the closest existing node in the hydraulic model.

Diurnal Curve

A diurnal curve represents the average hourly demand fluctuation in a water system. The diurnal curve for Kyle's potable distribution system is created based on hourly production and tank level information from SCADA system. The estimated diurnal curve representing the average hourly demand fluctuation of both pressure zones on October 29, 2013 is presented in **Figure 3.2.1**. Residential areas are associated with high peaking factors and peaking is typically observed in the evenings.

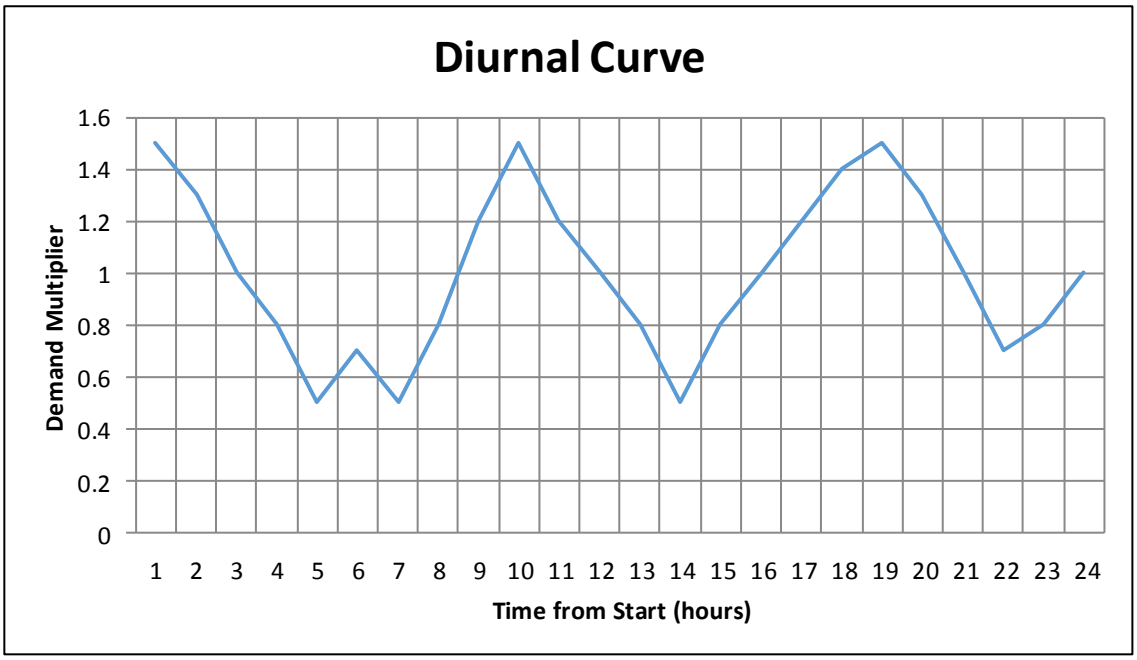


Figure 3.2.1 Diurnal Curve

3.3 Population Projections

Population within Kyle's service area is utilized to analyze existing and future water needs. The population data are obtained from the following sources:

- United States Census Bureau
- Kyle Economic Development

Baseline Population

Population for the year 2013 for Kyle's service areas are considered to be representative of the baseline population. Population within the service area is estimated by the United States Census Bureau's estimate population of 31,760.

Future Population
Population projections were estimated for the next 20 years using the baseline population and a projected annual growth percentage of 4.2 obtained from the Kyle Economic Development. Population projections are shown below.

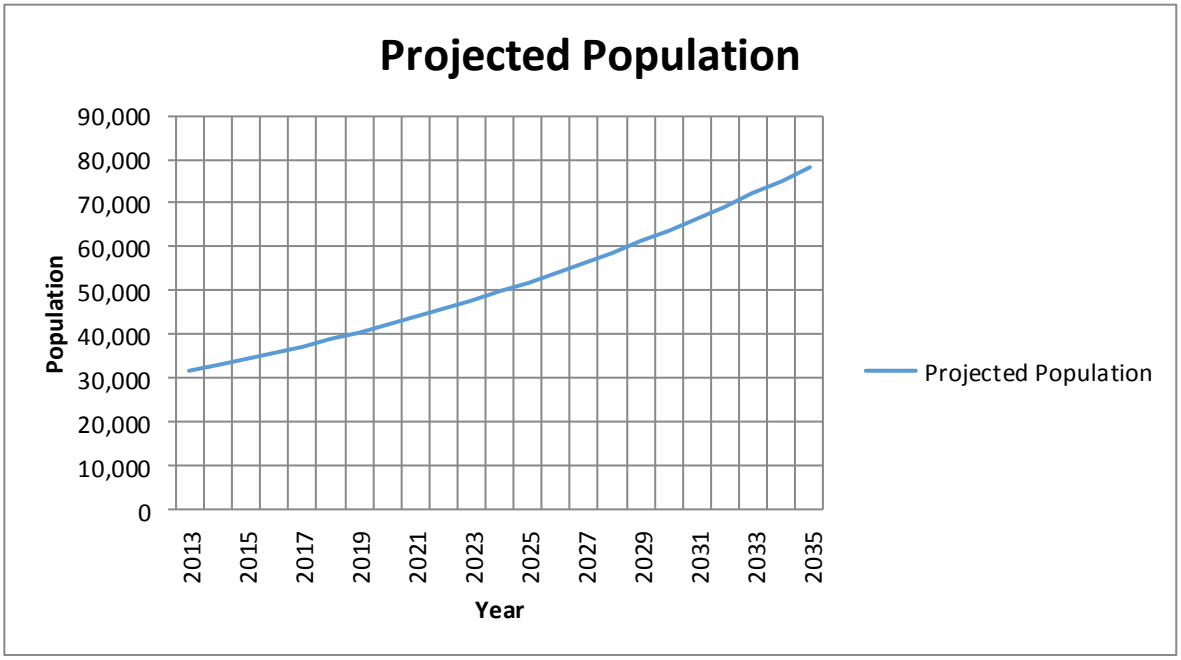


Figure 3.3.1 Projected Population

Existing Per Capita Water Use
The existing per capita water use is 64 gallons per capita per day (gpcd). This is found by dividing the 2013 user consumption of 2,022,798 gpd (1,405 gpm) by the year 2013 estimated population of 31,760.

Future Consumption
Future consumption requirements for Kyle's service areas are estimated based on development projections. The existing land use within the Kyle's water distribution system is estimated to be 6,000 acres based on the 2013 land use shapefile obtained from the City. A consumption per acre value of 0.28 gpm/acre is estimated by dividing the 2013 total water production by the existing land use. For future subdivisions with unknown projected demands, the consumption per acre value is multiplied by each future subdivision acreage to estimate the average future demand for the total acreage as shown in **Table 3.4**. Future subdivisions with average demands based on developer's projections are designated in **Table 3.4**. Future subdivision and corresponding acres were supplied by Kyle City staff.

Table 3.3.1: Summary of Future Subdivisions/Land Use		
Subdivision	Acre	Projected ADD (gpm)
Anthem[1]	674	281
Aztec	672	190
Blanco River Ranch[1]	2,167	222
BRI/McCoy	3,059	865
Brooks R-3-3	16	5
Brookside Phase 2	36	10
Bunton Creek Remaining Phases	90	25
Cool Springs	125	35
Creekside at Bunton Creek	98	28
Creekside Village	73	21
Crosswinds MUD	444	125
Cypress Forest	130	37
Drenner Group	56	16
Fairway Landing Apartments	15	4
Hays Commerce Park[1]	106	73
Hays Junction Apartments	24	7
Intermandeco/Driskell	169	48
Kyle Estates East (Walton)	300	85
Kyle Estates West (Walton)	331	94
Kyle Ranch[2]	57	59
La Salle MUD	2,740	775
Lehman Tract	98	28
Nance	2,934	830
Oak on Goforth Apts	10	3
Oaks on Marketplace	14	4
Pecan Woods	768	217
Plum Creek Phase 2[1]	606	518
Stagecoach Forest	73	21
Sunset Hills	53	15
The Strand Apartments	8	2
Trails at Plum Creek Apartments	12	3
Twin Creeks	98	28
Vistas at Plum Creek Apartments Phase 2	7	2
Woodlands Phases 3-5	75	21
Note: 1. Projected ADD estimated based on developer's projections.		

Future Demand

The estimated average daily demand for the year 2035 is 4,090 gpm. This is found by multiplying the projected 2035 user consumption of 3,466 gpm with an estimated 18-percent water loss. The 2035 user consumption was found by multiplying the estimated year 2035 population of 78,357 by the per capita water use of 64 gpcd. Using peak day and peak hour multipliers of 1.566 and 3.0, the projected 2035 maximum day and peak hour demands are 6,405- and 12,270 gpm.

The projected estimated average daily demand for the next 20 years in increments of 5 years is shown in **Figure 3.3.2** on the following page.

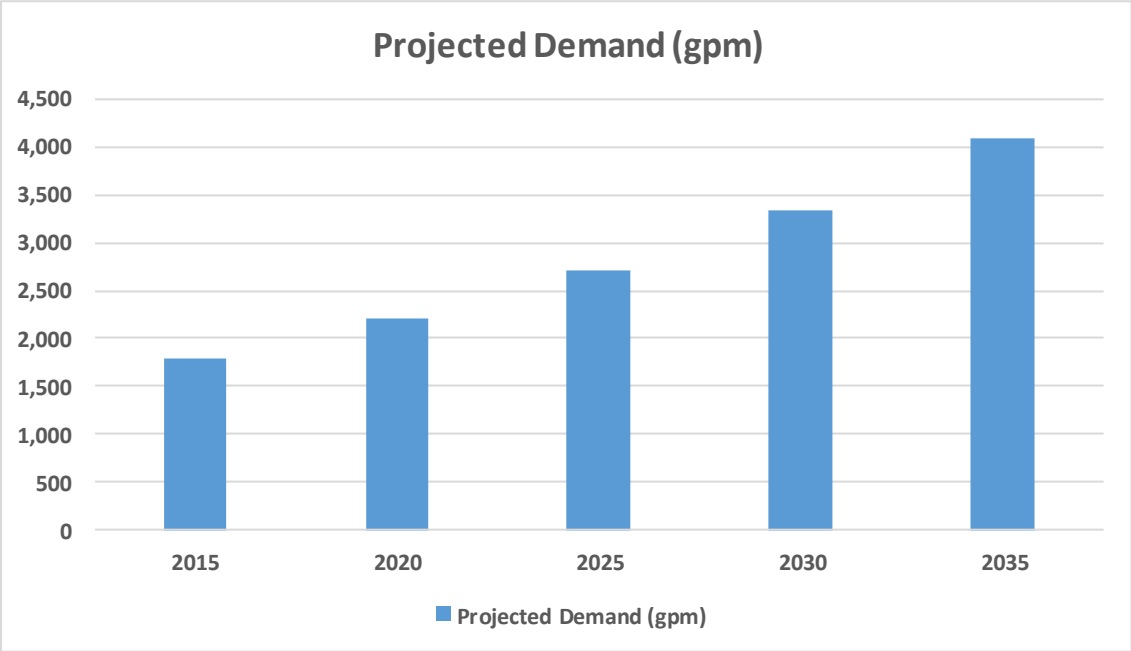


Figure 3.3.2 Projected Demand

Section 4.0 Hydraulic Model Development and Calibration

4.1 Model Calibration

The hydraulic model with the existing system configuration and demands is calibrated to improve the accuracy of the model results and provide a planning tool that can be used to identify system deficiencies and recommend improvements address system deficiencies. Model calibration is the process of comparing model results with field results as closely as possible. Typical calibration adjustments include the following:

- Pump curve
- Incorrect GIS connectivity
- Variation in tank levels
- Elevations
- Variations in pipe roughness coefficients
- Closed valves

The hydraulic model is calibrated for two scenarios:

- **Steady State Calibration:** Simulating fire hydrant flow tests to match field results

- **24-hour Extended Period Simulation (EPS) Calibration**: Modifying the model until it mimics SCADA records.

Steady State Calibration
A steady state calibration was performed for 30 locations throughout the distribution system. Hydrant tests were conducted by City personnel. Each test consists of opening a fire hydrant (indicated as a flowing hydrant) and flowing the open hydrant. The flow measured at the hydrant is then input to the hydraulic model as an additional demand and the pressures at the node that represent the static hydrant location are compared to field results. The locations of the fire hydrant tests are shown in **Appendix C**. The results from all hydrant tests are presented in **Table 4.1.1**.

The initial hydrant tests were performed between February 3, 2015 and February 5, 2015. Tank levels for Plum Creek, North Old Stagecoach Road, Well 4 Kohler's Crossing, Dacy, Post Oak, and Roland were adjusted to match SCADA records for each test. The model calibration was simulated with one booster pump at each station in operation. Average operating tank levels were assumed when SCADA records were unavailable.

Additional hydrant testing for locations that were out of tolerance were performed on August 5, 2015. During the test, the Dacy and Post Oak Tanks were adjusted to match SCADA records for each test. The model calibration was simulated with one booster pump at each station in operation. For test levels missing SCADA records, average tank levels were assumed.

Before calibration, a Hazen-Williams coefficient of 130 was used for all pipeline. The Hazen-Williams coefficient was adjusted to 104 for ductile iron and asbestos cement pipe.

As shown in **Table 4.1.2**, several of the hydrant results have a flowing hydrant pressure drop less than 10 psi. Flowing hydrant field test results that did not exhibit a minimum 10 psi drop in pressure are not considered useful for calibration. Flowing hydrants exhibiting low pressure drops will result in less flow making calibration less sensitive. Because friction or head loss increase exponentially with the Hazen-Williams equation, higher flows intensify such losses, resulting in a pronounced lowering of the hydraulic gradeline (HGL). With the HGL lowered, modeling results are more sensitive to roughness coefficients, which, in turn, allows for ease and accuracy in determining roughness coefficients. If a single hydrant does not sufficiently produce enough head loss, it is recommended that additional hydrants be opened simultaneously to further lower the HGL.

Based on **Table 4.1.1** results, the low pressure zone is operating at a higher hydraulic gradeline than what the model is predicting. ***Field tests are suggesting many locations in the low pressure zone to be operating at a hydraulic gradeline approximately 15 feet higher than the tank operating levels.***

Record drawings and SCADA records were used to confirm a 1626 tank operating level of approximately 758- to 778 feet. Kyle Parkway Tests 1 and 2, located on the 16-inch main that feeds the 1626 tank, show a field observed hydraulic gradeline ranging from 840- to 844 feet with static pressure readings of 48 psi. ***This suggests the 16-inch main hydraulic gradeline is approximately 70 feet higher than the 1626 tank hydraulic gradeline, and the 1626 tank fill valve would remain partially closed to prevent overflowing the tank***. Kyle Parkway Tests 1 and 2 model results predict a hydraulic gradeline ranging from 825- to 832 feet with static pressure results of approximately 40 psi. The low model predicted pressures are a result of high elevation locations of approximately 730 feet.

Table 4.1.1 City of Kyle Hydrant Test Results

Test Number	Date of Test	Time of Test	Location Description	Zone (High/ Low)	Field Available FF (gpm)	Static Tests					Residual Tests				
						Observed HGL (ft)	Obversed Pressure (psi)	Simulated HGL (ft)	Simulated Pressure (psi)	Change in Pressure (psi)	Obversed HGL (ft)	Obversed Pressure (psi)	Simulated HGL (ft)	Simulated Pressure (psi)	Change in Pressure (psi)
Test-1	4-Feb-15	15:00	Powell	High	919	930.23	58	924.27	55	-3	921.03	54	918.62	53	-1
Test-2	3-Feb-15	15:30	Fairway	High	1,126	927.65	70	924.34	69	-1	923.03	68	920.34	67	-1
Test-3	4-Feb-15	16:05	Negley	High	839	929.01	61	923.14	58	-3	926.70	60	921.94	58	-2
Test-4	4-Feb-15	16:25	McNaughton	High	1,126	929.39	70	923.32	67	-3	924.79	68	920.69	66	-2
Test-5	4-Feb-15	16:50	McGarity	High	1,126	931.18	90	923.67	87	-3	912.77	82	919.45	85	3
Test-6	4-Feb-15	9:00	Spring Branch Loop	High	1,245	928.09	90	922.37	88	-2	918.88	86	909.51	82	-4
Test-7	4-Feb-15	10:00	Mather	High	993	926.68	72	922.38	70	-2	926.68	72	918.59	68	-4
Test-8	4-Feb-15	10:45	Spring Branch Drive	High	1,300	927.28	86	922.45	84	-2	913.46	80	888.78	69	-11
Test-9	4-Feb-15	11:20	W Schlemmer St	Low	839	853.65	48	854.39	48	0	830.63	38	838.24	41	3
Test-10	4-Feb-15	11:00	Rebel Dr	High	1,062	927.26	66	923.35	64	-2	927.26	66	918.96	62	-4
Test-11	4-Feb-15	11:50	Camelia Parkway	High	993	927.56	66	923.44	64	-2	922.96	64	919.97	63	-1
Test-12	4-Feb-15	12:10	Gregg Dr	High	751	925.26	70	922.84	69	-1	856.20	40	851.97	38	-2
Test-13	4-Feb-15	14:00	Miller St	Low	839	854.73	56	853.16	55	-1	836.31	48	837.65	49	1
Test-14	4-Feb-15	14:20	Johnny's Way	Low	650	848.51	44	847.90	44	0	797.87	22	795.88	21	-1
Test-15	4-Feb-15	16:40	Quail Ridge Dr	Low	919	841.33	64	842.39	64	0	818.31	54	820.14	55	1
Test-16	4-Feb-15	17:10	Old Post Rd	Low	839	843.52	58	839.61	56	-2	843.52	58	836.28	55	-3
Test-17	5-Feb-15	10:00	Atlantis	Low	1,062	844.86	70	834.00	65	-5	840.26	68	831.97	64	-4
Test-18	5-Feb-15	10:25	Verano Dr/Estival Dr	Low	993	846.93	74	834.20	68	-6	837.72	70	825.91	65	-5
Test-19	5-Feb-15	10:45	Masonwood Dr	Low	1,062	852.90	70	833.52	62	-8	843.69	66	828.78	60	-6
Test-20	5-Feb-15	11:10	Goldenrod St	Low	1,062	849.07	78	834.80	72	-6	835.25	72	825.15	68	-4
Test-21	5-Feb-15	11:30	Goforth Rd	Low	993	856.35	78	833.95	68	-10	842.54	72	830.10	67	-5
Test-22	5-Feb-15	11:50	Brandi Cir	Low	1,062	854.88	80	835.27	72	-8	841.07	74	826.25	68	-6
Test-23	5-Feb-15	12:05	Buton Creek Rd	Low	1,126	860.08	76	840.15	68	-8	846.27	70	834.06	65	-5
Test-24	5-Feb-15	13:35	Onyx Lake Dr	Low	993	863.66	74	844.97	66	-8	849.85	68	832.65	61	-7
Test-25	5-Feb-15	13:55	Dacy Ln	Low	993	857.57	70	836.05	61	-9	852.96	68	835.50	60	-8
Test-26	5-Feb-15	14:20	Physicians Ways	Low	919	848.76	56	836.83	51	-5	839.55	52	832.88	49	-3
Test-27	5-Feb-15	14:40	Old Bridge Trail	High	1,245	930.44	94	924.75	92	-2	907.42	84	903.31	82	-2
Test-28	5-Feb-15	15:00	Seton Parkway	Low	1,062	836.48	70	836.12	70	0	827.27	66	832.37	68	2
Test-29	5-Feb-15	15:32	Nottingham Loop	Low	919	847.25	62	835.79	57	-5	824.23	52	824.25	52	0
Test-30	5-Feb-15	15:45	Marquitos Drive	Low	919	847.80	72	835.78	67	-5	808.67	55	818.86	59	4
Test-19 Re-test	5-Aug-15	10:06	Masonwood Dr	Low	1,060	825.27	58	822.63	57	-1	816.07	54	822.63	57	3
Test-21 Re-test	5-Aug-15	9:20	Goforth Rd	Low	1,060	840.23	71	825.88	65	-6	833.33	64	825.88	61	-3
Test-22 Re-test	5-Aug-15	9:01	Brandi Cir	Low	1,060	838.77	73	825.79	67	-6	827.26	68	825.79	67	-1
Test-23 Re-test	5-Aug-15	15:50	Buton Creek Rd	Low	1,190	846.27	70	836.19	66	-4	832.46	64	836.19	66	2
Test-25 Re-test	5-Aug-15	16:10	Dacy Ln	Low	1,130	843.76	64	827.76	57	-7	841.45	63	827.76	57	-6
Test-26 Re-test	5-Aug-15	9:44	Physicians Way	Low	920	844.16	54	832.28	49	-5	834.95	50	832.28	49	-1
Kyle Parkway Test 1	5-Aug-15	14:08	HEB gas	Low	920	840.50	48	824.25	41	-7	835.89	46	824.25	41	-5
Kyle Parkway Test 2	5-Aug-15	14:40	1626/Marketplace	Low	920	844.22	48	825.35	40	-8	835.01	44	825.35	40	-4

Table 4.1.2 City of Kyle Hydrant Test Results - Observed Pressure Drop							
Test Number	**Date (2015)**	**Time**	**Location Description**	**Zone (High /Low)**	**Obversed Static Pressure (psi)**	**Obversed Residual Pressure (psi)**	**Obverved Pressure Drop Comparison (psi)**
Test-1	4-Feb	15:00	Powell	High	58	54	4
Test-2	3-Feb	15:30	Fairway	High	70	68	2
Test-3	4-Feb	16:05	Negley	High	61	60	1
Test-4	4-Feb	16:25	McNaughton	High	70	68	2
Test-5	4-Feb	16:50	McGarity	High	90	82	8
Test-6	4-Feb	9:00	Spring Branch Loop	High	90	86	4
Test-7	4-Feb	10:00	Mather	High	72	72	0
Test-8	4-Feb	10:45	Spring Branch Drive	High	86	80	6
Test-9	4-Feb	11:20	W Schlemmer St	Low	48	38	10
Test-10	4-Feb	11:00	Rebel Dr	High	66	66	0
Test-11	4-Feb	11:50	Camelia Parkway	High	66	64	2
Test-12	4-Feb	12:10	Gregg Dr	High	70	40	30
Test-13	4-Feb	14:00	Miller St	Low	56	48	8
Test-14	4-Feb	14:20	Johnny's Way	Low	44	22	22
Test-15	4-Feb	16:40	Quail Ridge Dr	Low	64	54	10
Test-16	4-Feb	17:10	Old Post Rd	Low	58	58	0
Test-17	5-Feb	10:00	Atlantis	Low	70	68	2
Test-18	5-Feb	10:25	Verano Dr/Estival Dr	Low	74	70	4
Test-19	5-Feb	10:45	Masonwood Dr	Low	70	66	4
Test-20	5-Feb	11:10	Goldenrod St	Low	78	72	6
Test-21	5-Feb	11:30	Goforth Rd	Low	78	72	6
Test-22	5-Feb	11:50	Brandi Cir	Low	80	74	6
Test-23	5-Feb	12:05	Buton Creek Rd	Low	76	70	6
Test-24	5-Feb	13:35	Onyx Lake Dr	Low	74	68	6
Test-25	5-Feb	13:55	Dacy Ln	Low	70	68	2
Test-26	5-Feb	14:20	Physicians Ways	Low	56	52	4
Test-27	5-Feb	14:40	Old Bridge Trail	High	94	84	10
Test-28	5-Feb	15:00	Seton Parkway	Low	70	66	4
Test-29	5-Feb	15:32	Nottingham Loop	Low	62	52	10
Test-30	5-Feb	15:45	Marquitos Drive	Low	72	55	17
Test-19 Re-test	5-Aug	10:06	Masonwood Dr	Low	58	54	4
Test-21 Re-test	5-Aug	9:20	Goforth Rd	Low	71	64	7
Test-22 Re-test	5-Aug	9:01	Brandi Cir	Low	73	68	5
Test-23 Re-test	5-Aug	15:50	Buton Creek Rd	Low	70	64	6
Test-25 Re-test	5-Aug	16:10	Dacy Ln	Low	64	63	1
Test-26 Re-test	5-Aug	9:44	Physicians Way	Low	54	50	4
Kyle Parkway Test 1	5-Aug	14:08	HEB gas	Low	48	46	2
Kyle Parkway Test 2	5-Aug	14:40	1626/Marketplace	Low	48	44	4

Extended Period Calibration

A model calibrated for a steady-state scenario provides an instantaneous snapshot of a water distribution system. An extended period simulation (EPS) model provides time steps so a better understanding of the operations of a water distribution model can be analyzed. The goal of the EPS calibration is to estimate the accuracy with which the model simulates the field operations over a 24-hour period. The modeled versus field data for the storage tanks, booster stations, and groundwater wells are presented in **Appendix D**.

The modeled versus field data represents field conditions from October 29, 2013.

The model simulation is predicting the 1626 tank filling up prior to the other tanks in the low pressure zone. A flow control valve was added at the 1626 inlet to limit the flow into the 1626 to match 1626 tank SCADA levels.

Water Age

Water age refers to the time it takes for water to travel from sources to consumers, and it depends on flow velocities and pipe lengths in the distribution system. Water age is a major factor contribution to water quality deterioration within the distribution system and is primarily controlled by system design and system demands. Thus, water age can vary significantly within a given system. Increasing water age increases the reaction time, allow for additional formation of contaminants that can lead to adverse health effects. Water quality problems that can be found by increased water age include disinfection byproduct formation, corrosion control effectiveness, nitrification, and microbial growth/regrowth. The City of Kyle water distribution model was run in EPS to determine water age within the distribution system with results shown in **Appendix E**.

The Water Industry Database (AWWA and AWWA RF 1992) indicate an average distribution system retention time of 1.3 days and a maximum retention time of 3.0 days based on a survey of more than 800 U.S. utilities. There are several indicators that may suggest high water age. These include aesthetic considerations that may be identified by consumers, as well as results of distribution monitoring. However indicators can also be triggered by factors other than water age, such as insufficient source water treatment, pipe materials, and condition/age of distribution system. Aesthetic indicators include poor taste and odor, discoloration, and water temperature. Monitoring indicators include depressed disinfectant residual, elevated DBP levels, and elevated bacterial counts.

Flushing is the most common method of reducing water age. Other solutions include increasing tank turnover, changing controls for variable speed pumps and control valves, closing valves, reducing storage volume, eliminating dead ends, and using multiple supply sources.

Calibration Conclusions

The American Water Works Association (AWWA) Manual of Water Supply Practices M32 provides guidelines for computer modeling of water distribution systems. Recommended Hydraulic Grade Line (HGL) predications should be approximately 3 psi, or 7 feet. The tank water level fluctuations predicted in the model should be within 3 to 6 feet of those recorded in the field.

Locations that meet the guidelines described above can be used for long term planning; however, additional analysis is recommended for the Hydrant Tests shown in **Table 4.1.3** and the Hydrant Test Locations Out of Tolerance shown in **Appendix C** prior to long term planning at or near these locations:

Table 4.1.3: Summary of Hydrant Tests Out of Tolerance

Test Number	Change in Static Pressure (psi)
17	-5
18	-6
20	-6
21	-6
22	-6
23	-4
24	-8
25	-7
26	-5
29	-5
30	-5
Kyle Parkway Test 1	-7
Kyle Parkway Test 2	-8

The following items were evaluated for all Hydrant Test locations that fell out of tolerance:

- **Pump curves**

  See **Appendix B** for pump curves. B&N contacted pump manufacturer's to obtain pump curves generated from nameplate photos taken by City personnel. Pump curves were successfully obtained from each booster pump station.

- **Incorrect GIS connectivity**

  The pipeline connectivity in the model is assumed to be accurate and is representative of the City's GIS system (provided by the City of Kyle).

- **Variation in tank levels**

  GPS elevations were taken to confirm tank base elevations with contours and record drawings. Tank levels were estimated from Record drawings. SCADA information was used to verify the tank levels.

- **Elevations**

  The model elevations represent two-foot contour shapefiles obtained from the City. The most recent contour information was downloaded from the Texas Natural Resources Information System website and compared to model elevations to confirm accuracy.

- **Variations in pipe roughness coefficients**

  The Hazen-Williams coefficient was adjusted from 130 to 104 for ductile iron and asbestos cement pipe. Further adjusting the roughness coefficients had a negligible impact on improving calibration results.

- **Closed valves**

  B&N provided the City with a map representing closed valves used for model calibration. The model was updated with the confirmed valve positions verified by City personnel. The valve positions were confirmed to be closed at all zone boundaries.

The following items are recommendations to improve the predictive capability of the model in the future:

1. Verify operability of hydrant testing equipment.
2. Verify GIS pipe connectivity and pipe diameter at out of tolerance locations.
3. Installation of flow meters between zones upstream and downstream of the PRV located on Marketplace Avenue.
4. Installation of pressure loggers to capture pressures at hydrant locations listed in **Table 4.1.3** and additional key areas such as pump discharge. Record all tank levels and pump operating conditions from SCADA.
5. Check for closed or partially closed valves in the 16-inch main that fills the 1626 tank.
6. Verify low pressure zone tank HGL ranges displayed in **Table 4.1.2**.

Section 5.0 Recommendations Criteria

5.1 Distribution System Recommendation Criteria

Design criteria are established for the evaluation of Kyle's potable water system. The criteria are based on industry standards that are typical ranges of values that are acceptable. The design criterion for this evaluation is presented in **Table 5.1.1**.

Table 5.1.1: Summary of Distribution System Recommendation Criteria

Evaluation Criteria	Value	Units	Evaluation Demand Condition
System Pressure			
Maximum Pressure	100	psi	MinDD
Minimum Pressure, normal conditions	35	psi	PHD
Minimum Pressure, with fire flow	20	psi	MDD
Minimum Fireflow			
Residential	500	gpm	MDD
Commercial	2,000	gpm	MDD
Schools	2,250	gpm	MDD
Water Age			
Maximum water age	4	days	EPS
Distribution System			
Pipeline Life Expectancy	75	years	n/a
Minimum Diameter for new pipe	6	inches	n/a
Maximum Pipeline Velocity			
Pipelines	5	fps	MDD
Pump Station suction pipelines	4	fps	MDD
Maximum Pipeline Headloss			
Pipeline 16-inches and larger	3/1,000	ft/ft	MDD
Pipeline less than 16-inches	10/1,000	ft/ft	MDD
Supply Capacity			
Entire System	Provide MDD with largest single source out of service		MDD
By Pressure Zone	Provide MDD with firm transfer/booster capacity between zones		MDD

System Pressures
Minimum system pressures are evaluated at Peak Hour Demand (PHD). The minimum pressure criterion for normal PHD conditions is 35 pounds per square inch (psi), while the minimum pressure under MDD with fire flow conditions is 20 psi. The pressure analysis is limited to demand nodes because only locations with service connections need to meet such

pressure requirements. Lower pressures are acceptable for junctions at water system facilities and on transmission mains that have no service demands.

Minimum Fireflow
The minimum fireflow values shown in **Table 5.1.1** represent generally accepted ISO recommended fire flow ranges in a distribution system. These are typically acceptable fire flows determined by ISO and the Fire Code.

The model calculates fire flow at each hydrant by setting a minimum residual pressure of 20 psi so the software calculates the amount of fireflow available such that the residual pressure at each hydrant does not fall below this target pressure.

Water Age
The Water Industry Database (AWWA and AWWA RF 1992) indicate an average distribution system retention time of 1.3 days and a maximum retention time of 3.0 days based on a survey of more than 800 U.S. utilities. Based upon this information, the water age that is 4.0 days or more is identified.

Pipeline Velocities
The maximum velocity is 5 feet per second (fps) provided that the system pressures are sufficient. This criterion is intended to minimize head loss. This criterion does not apply to flow in fire hydrant laterals. The design velocity for transmission mains should consider energy requirements and pipeline length to determine the optimal diameter rather than use a fixed velocity criterion.

Storage
The total storage required for a water distribution system is evaluated in three parts: 1) storage for operational use 2) storage for firefighting and 3) storage for emergencies. These three components are determined by pressure zone in order to evaluate the ability of the water system to meet the storage criteria on both an inter-zone basis as well as a system-wide basis.

Operational Storage
Operational storage is defined as the quantity of water that is required to balance daily fluctuations in demand and water production. It is necessary to coordinate the water source production rates and the available storage capacity in a water system to provide a continuous treated water supply to the system. Water systems are usually designed to supply the average demand on the maximum day and use reservoir storage to supply water for peak hour flows that typically occur in the mornings and late afternoons. The operational storage is replenished during off-peak hours and typically occurs during nighttime when the demand is low. The American Water Works Association (AWWA) recommends that an operational supply volume ranging from one-quarter to one-third of the demand during one maximum day. Current industry practice is to turnover 20-percent of the tank every day. Theoretically this means that the stored water is never more than 5 days old.

Fire flow Storage
Fire protection is usually the dominant component in smaller systems. This component is sized by determining the design fire in each district and making sure the system provides this.

The design fire is an assumption based on a number of factors. The main sources for this information are local fire departments' requirements and organizations like ISO, Inc. that publish fire protection data. ISO will also review a system and evaluate it against its baseline fire protection criterion to determine how effective it is. The ISO report can be a great resource for selecting the proper design fire for a utility. ISO states that the maximum fire flow rate a community water system is expected to provide is 3,500 gpm for three hours. This is a common starting point for this analysis.

Emergency Storage
The volume of water that is needed during an emergency is usually based on the estimated amount of time expected to lapse before the emergency is corrected. Possible emergencies include water contamination, several simultaneous fires, unplanned electrical outages or pipeline ruptures or other unplanned events. Typically, emergency storage is set as a percentage of MDD. However, this percentage needs to be based on the water system layout and facilities. Kyle has a large number of groundwater wells throughout the distribution system, so they are less vulnerable in emergencies.

Supply Capacity
The system demands should be met under MDD conditions with the largest water supply source out of service.

The water supply reliability is evaluated for the entire system and on a pressure zone basis using a spreadsheet model that calculates the water supply balance by pressure zone.

Section 6.0 System Evaluation

The Kyle water distribution system is evaluated for the following phases herein:

- **Section 6.1:** Existing – Year 2016
- **Section 6.2:** Future – Year 2022
- **Section 6.3:** Future – Year 2035

Hydraulic deficiencies based on the Distribution System Recommendation Criteria outlined in **Section 5** are identified in this Section.

Pressure, Available Fireflow and Velocity, and Water Age maps for Years 2013, 2016, 2022, and 2035 are displayed in **Appendix E**.

6.1 Existing System Evaluation – Year 2016

Minimum Pressure during Peak Hour Demand
The following locations with pressures below 45 psi have been identified; however, no improvement projects have recommended at this time because pressures at these locations are above the recommended minimum pressure of 35 psi at peak hour demands.

1. **Dacy Loop**
   There are high elevation locations along the 16-inch Dacy Loop pipeline in the low pressure zone that result in low pressures.

2. **Plum Creek**
   There are high elevation locations along the 4-inch pipeline near the Plum Creek tank in the high pressure zone that result in low pressures.

3. **Kyle Parkway**
   There are high elevation locations along the 16-inch Kyle Parkway pipeline in the low pressure zone that result in low pressures.

4. **Downtown**
   There are low pressures in pipeline ranging from 2- to 8-inches located downtown in the low pressure zone.

Maximum Pressure during Minimum Daily Demand (MinDD)
There are no locations with pressures above 100 psi at these conditions.

Minimum Fireflow during Maximum Daily Demand (MDD)

1. **West Blanco Street**
   Increasing the pipeline from 6-inch to 8-inches in diameter will increase fireflows to the acceptable range for schools.

Water Age
Water age locations that are 4.0 days or more are displayed in **Appendix E**.

1. Flushing water out of a zone will lower the water age, but the volume requirements are large. Adding a single flushing location of 200 gpm for twenty-four hours a day will reduce water age in the district. This option would have the least cost to implement, but might face public and political opposition as well as high operating and labor costs.

2. Dead end locations with high water age that are in close proximity to the future subdivision areas can be looped to improve water age.

Maximum Pipeline Velocity and Headloss during Maximum Daily Demand (MDD)

1. **Well 2 transmission main**
   This improvement will result in decreasing velocity and headloss to the acceptable range.

2. **Lehman transmission main**
   This improvement will result in decreasing velocity and headloss to the acceptable range.

3. **South Old Stagecoach Road**
   This improvement will result in decreasing velocity and headloss to the acceptable range.

Supply Evaluation
A water supply analysis is performed to determine if available water sources are sufficient to meet MDD. The estimated MDD for Kyle in year 2016 is 2,929 gpm. In addition, Kyle is committed to supply Hays Caldwell Public Utility Agency (HCPUA) with a total supply of 0.5 million gallons per day (MGD) or 347 gpm through Year 2023. This results in a total 2016 MDD of 3,276 gpm as shown in **Table 6.1.1**. The amount of excess supply with all sources and with the largest source out of service are evaluated based on factory pump curve design flow rates and City of Kyle 2013 field data.

There is excess supply with all sources and the largest source out of service in Year 2016.

Table 6.1.1: Water Distribution System Supply Evaluation		
Source		
	Source[1]	**Source[2]**
Well 1 (gpm)	650	524
Well 2 (gpm)	550	623
Well 3 (gpm)	425	490
Well 4 (gpm)	470	650
Well 5 (gpm)	650	748
GBRA Lehman (gpm)	750	1,292
GBRA Yarrington (gpm)	1,100	1,484
HCPUA (gpm) (Year 2023-2026)	1,438	
HCPUA (gpm) (Year 2027-2029)	2,668	
HCPUA (gpm) (Years 2030-2034)	3,929	
HCPUA (gpm) (Year 2035)	5,763	
Year 2016		
MDD (gpm)	3,276	
Excess Supply - All Sources (gpm)	1,319	2,535
Excess Supply - Largest Source Out (gpm)	219	1,051
Year 2022		
MDD (gpm)	4,097	
Excess Supply - All Sources (gpm)	498	1,714
Excess Supply - Largest Source Out (gpm)	N/A	230
Year 2023		
MDD (gpm)	3,910	
Excess Supply - All Sources (gpm)	2,123	3,339
Excess Supply - Largest Source Out (gpm)	685	1,901
Year 2027		
MDD (gpm)	4,610	
Excess Supply - All Sources (gpm)	2,653	3,869
Excess Supply - Largest Source Out (gpm)	N/A	1,201
Year 2030		
MDD (gpm)	5,215	
Excess Supply - All Sources (gpm)	3,309	4,525
Excess Supply - Largest Source Out (gpm)	N/A	596
Year 2035		
MDD (gpm)	6,150	
Excess Supply - All Sources (gpm)	4,208	5,424
Excess Supply - Largest Source Out (gpm)	N/A	N/A
Note: 1. Flows are based on factory pump curve design points with largest pump out of service (Appendix B). 2. Flows are based on Firm Water Supply Rates of Delivery metered data from City of Kyle 2013 data with largest pump out of service (reference Appendix B).		

Pumps
The City of Kyle water distribution systems booster station pumps factory curve design flows are compared to metered flows and are ranked by descending field to factory ratio in **Table 6.1.2.**

Table 6.1.2: Water Distribution System Booster Station Pumps

Pump	Factory Curve Design Flow (gpm)[1]	City of Kyle 2013 metered flow (gpm)[2]	Field to Factory Ratio (%)
Lehman	750	1,310	174
Yarrington	550	742	135
Well 3	425	490	115
Well 5	650	748	115
Well 2	550	623	113
Rebel Road Service	750	850	113
1626	500	811	108
Well 3 Outside	1,000	935	94
Well 1	650	524	81
Well 4	N/A	650	N/A
Well 3 Control Room	500	N/A	N/A

Note: 1. Flows are based on factory pump curve design points (Appendix B). 2. Flows are based on Firm Water Supply Rates of Delivery metered data from City of Kyle 2013 data (Appendix B). The average metered flow was taken for identical pumps.

Since many of the booster pumps are operating far from the design point, it is recommended that further evaluation be performed to determine if a more efficient pump could replace the existing pumps.

Under ideal circumstances, a pump will not operate at flows greater than Best Efficiency Point (BEP) plus 10 percent or flows less than BEP minus 10 percent. There are many consequences when operating a pump too far to the left or right of its BEP for a sustained period of time. ***Some of these effects can include cavitation, vibration, and impeller damage. Pumps that are operating out of the 10 percent tolerance include Lehman, Yarrington, Well 3, Well 5, Rebel Road Service, and 1626.***

System Storage Evaluation
The existing distribution system consists of a total storage volume of approximately 4.8 MG. A storage analysis is performed for each zone as shown in **Table 6.1.2**. As shown in the table, there are no storage deficiencies in the existing system in Year 2016.

Table 6.1.3: Water Distribution System Storage Evaluation

Criteria (unit)	High Pressure Zone - 2013 Demands	High Pressure Zone - 2016 Demands	High Pressure Zone - 2022 Demands	High Pressure Zone - 2035 Demands	High Pressure Zone - 2035 Demands with Third Pressure Zone	Low Pressure Zone - 2013 Demands	Low Pressure Zone - 2016 Demands	Low Pressure Zone - 2022 Demands	Low Pressure Zone - 2035 Demands	Potential Third Pressure Zone - 2035 Demands
Average daily demands (gpm)	716	780	1,002	1,707	626	998	1,088	1,397	2,380	1,081
Maximum day demands (gpm)	1,121	1,222	1,570	2,674	977	1,563	1,704	2,188	3,727	1,697
Peak hour demands (gpm)	2,148	2,341	3,007	5,122	1,879	2,994	3,263	4,192	7,139	3,243
Booster pump firm capacity (gpm)	2,220	2,220	2,220	2,220	2,220	3,350	3,350	3,350	3,350	1,697[1]
Design fire flow (gpm)	3,500	3,500	3,500	3,500	3,500	3,500	3,500	3,500	3,500	3,500
Design fire duration (hours)	3	3	3	3	3	3	3	3	3	3
Design fire flow supplied by storage (gpm)	2,401	2,502	2,850	3,954	2,257	1,713	1,854	2,338	3,877	3,500
Total fire flow storage capacity required (gal)	432,226	450,390	512,957	711,674	406,214	308,316	333,635	420,843	697,827	630,000
Balancing storage required (gal)	0	58,234	377,856	1,393,018	0	0	0	403,968	1,818,956	742,080
Desired emergency outage duration (hours)	6	6	6	6	6	6	6	6	6	6
Emergency outage required capacity (gal)	257,760	280,958	360,864	614,654	225,494	359,280	391,615	502,992	856,739	389,160
Subtotal Required storage capacity	**689,986**	**789,582**	**1,251,677**	**2,719,347**	**631,709**	**667,596**	**725,250**	**1,327,803**	**3,373,522**	**1,761,240**
Desired turnover percentage	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%
Required storage volume for desired turnover (gal)	137,997	157,916	250,335	543,869	126,342	133,519	145,050	265,561	674,704	352,248
Total Required storage capacity	**827,983**	**947,499**	**1,502,012**	**3,263,216**	**758,051**	**801,115**	**870,300**	**1,593,363**	**4,048,227**	**2,113,488**
Current storage capacity (gal)	1,891,000	1,891,000	1,891,000	1,891,000	1,891,000	2,900,000	2,900,000	2,900,000	2,900,000	N/A
Difference (gal) *Deficiencies will display in* **red**	1,063,017	943,501	388,988	(1,372,216)	1,132,949	2,098,885	2,029,700	1,306,637	(1,148,227)	N/A
Maximum sustainable storage capacity (gal)	5,155,200	5,619,168	7,217,280	12,293,090	4,509,890	7,185,600	7,832,304	10,059,840	17,134,782	N/A

Note: Blue values are input. Black and red values are calculated. 1. Booster Pump Firm Capacity is not yet determined and is an assumption based on MDD.

Distribution System
The existing distribution system consists of approximately 130 miles of pipeline with known installation dates between 1970 and 2014. Therefore, the pipeline is considered to be in satisfactory condition until the year 2045, when 2 percent of the pipeline will reach a life of 75 years. Approximately 27 percent of the pipe installation period is unknown but can be estimated for pipe age based on surrounding pipelines.

Existing Projects
The City has identified the following water main projects that were constructed by Year 2016. The projects were input into the model for all scenarios from Year 2016 on to determine impact on the distribution system.

1. **Marketplace Avenue Extension**
   This is a roadway project that will extend Marketplace Avenue to Burleson Road. The project will consist of approximately 3,600 feet of 12-inch pipeline.

2. **North Burleson Street Improvements**
   This is a roadway improvement project that will consist of replacing approximately 4,900 feet of 6- and 8-inch pipeline with 12-inch pipeline.

6.2 Future System Evaluation – Year 2022

In addition to the deficiencies described in **Section 6.1**, the following deficiencies are found in Year 2022:

Minimum Pressure during Peak Hour Demand
Low pressure areas in addition to those listed in Section 6.1 are listed below:

1. **Opal Lane**
   Increasing the pipeline from 2-inches to 8-inches and looping it to Johnny's Way will bring pressures above 35 psi.

2. **Blanco River Ranch, Kyle Ranch, and Anthem Future Development**
   There is an expected pressure deficiency in Blanco River Ranch, Kyle Ranch, and Anthem future developments due to high elevations served from the existing high pressure zone (930 feet tank overflow). Establishing a new pressure third pressure zone with higher tank operating levels will remedy the low pressures.

   A potential third pressure zone was developed in the model with a proposed elevated water storage tank at a ground elevation of 880 feet in the Anthem development. The proposed tank overflow is set at approximately 990 feet in order to maintain pressures between 35 and 90 psi. The proposed third pressure zone boundary will serve the Anthem, Plum Creek, and Blanco River Ranch customer locations that fall within the elevations of 780- to 910 feet. The Blanco River Ranch

development is separated into two different zones due to the wide range of elevations.

It is recommended that a supply pipeline connection to the existing system at the high pressure zone and a booster station be designed to serve the third pressure zone.

Future Subdivisions

The future development areas are listed in **Table 3.3.1 (Section 3.0)**. These pipelines have not yet been designed but are expected to be complete within the next five years.

The existing land use within the Kyle's water distribution system is estimated to be 6,000 acres based on the 2013 land use shapefile obtained from the City. An 87 ft/acre multiplier was used based on the total estimated footage of pipe 8-inches in diameter or less in the existing system divided by the current land use. 87 ft/acre was multiplied to each future estimated land area in acres obtained from the City to determine the estimated pipe length. A pipe diameter size of 8-inches in diameter was assumed. In addition, any large diameter pipeline connection to the existing distribution system was added in for each project.

The estimated footage of pipeline to serve the future subdivisions are the results of engineering analysis of the model results and not necessarily the results of any particular design criteria analysis. The estimated footage of pipeline only represents the connection from the existing system to the proposed future subdivision, and not the pipeline within each subdivision.

The projected demand for each future subdivision is based on developer's phased projections, where available. All other future subdivision demands are based on a yearly population growth of 4.2 percent as discussed in **Section 3.3** rather than assuming all future subdivision demands shown in **Table 3.3.1** will be met within 5 years.

High Pressure and Low Pressure Zone Supply Evaluation

A water supply analysis is performed to determine whether available water sources are sufficient to meet MDD. The estimated MDD for Kyle in year 2022 is 3,750 gpm. In addition, Kyle is committed to supply HCPUA with a total supply of 0.5 million gallons per day (MGD) or 347 gpm through Year 2023. This results in a total 2022 MDD of 4,097 gpm as shown in **Table 6.1.1**. The amount of excess supply with all sources and with the largest source out of service are evaluated based on factory pump curve design flow rates and City of Kyle 2013 field data.

There is excess supply with all sources and the largest source out of service in Year 2022 (based on average metered pump flow data).

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6.3 Future System Evaluation – Year 2035

In addition to the deficiencies described in **Section 6.1** and **Section 6.2**, the following deficiencies are found in Year 2035:

Supply Evaluation
A water supply analysis is performed to determine whether available water sources are sufficient to meet MDD. The estimated MDD for Kyle in year 2035 is 6,146 gpm. A future supply will be provided by HCPUA to Kyle from Year 2023 on. The expected maximum HCPUA supply to Kyle for each year is provided by the City and is displayed in Table **6.3.1**. The proposed supply location has been established at the Well 4 elevated tank. Currently the HCPUA pump station that will feed Kyle has not yet been located, but it is expected to be east of Kyle near the Hays County/Caldwell County line.

It is recommended that a minimum of additional a 500 gpm water source be provided in order to supply the entire system at MDD with the largest source out of service in the year 2035 (based on average metered pump flow data).

Pipelines with a diameter less than 6-inches
There is approximately 9.5 miles of pipeline that is less than 6-inches in diameter. It is recommended that this pipe be replaced with 6-inch pipe in the future. Increasing small diameter pipeline will improve fireflow throughout the system.

Storage Evaluation
A storage analysis is performed for the future system for each zone as shown in **Table 6.1.3**. As shown in the table, there are existing storage deficiencies in existing high and low pressure zones; however, adding a third pressure zone will reduce the storage deficiencies in the high pressure zone.

Storage recommendations:

- Third Pressure Zone: 2.11 MG of storage
- Low Pressure Zone: 1.15 MG of additional storage

A total of 3.3 MG of storage in recommended to serve future demands through the year 2035. Increasing overall storage in the system will provide reliability and redundancy during emergencies and provide adequate storage during fire protection.

Section 7.0 Capital Improvements Projects

This section describes the recommended Capital Improvement Program (CIP) for Kyle's potable water system. This CIP identifies the improvements necessary to address existing system deficiencies as well as new facilities required for increased water demands to provide continued reliable water service through the Year 2035. The recommended improvements are discussed first, followed by a discussion of the construction cost-estimating basis.

7.1 Recommended Improvements

The water distribution system and water facilities are evaluated using the criteria listed in **Table 5.1.1 (Section 5.0)**. This evaluation has been conducted for both existing water demand conditions and the projected future demands for Year 2035. Based on these evaluations, the recommendations are divided into three categories; 1) Priority 1 improvements and 2) Priority 2 improvements 3) Priority 3 improvements.

The improvement projects are divided into the following categories:

- Pipeline improvements for pressure deficiencies (P)
- Pipeline improvements to address fire flow deficiencies (FF)
- Pipeline improvements to address headloss and velocity deficiencies (HV)
- Pipeline added to serve future subdivisions (FS)
- Pipeline added for Pump Supply (PPS)
- Pump Supply (PS)
- Pump Replacement (PR)
- Small diameter pipeline replacement for pipelines with a diameter smaller than 6 inches (SD)
- Storage Improvements (S)

Priority 1 Potable Water System Improvements:

Table 7.1.1: Summary of Priority 1 Water System Improvements

Category	Improvements Description	Quantity	Unit
FF	Pipeline Improvements for fire flow deficiencies	0.4	miles
HV	Pipeline Improvements for headloss and velocity deficiencies	1.8	miles
FS	Pipeline addition for future subdivisions	5.7	miles
S	Storage Improvements	2.11	MG
PPS	Pipeline added for Pump Supply	1.2	miles
PS	Pump Supply from High Pressure Zone to Potential Third Pressure Zone	1,700	gpm
PR	Pump Replacement	5	Each

Priority 2 Potable Water System Improvements:

Table 7.1.2: Summary of Priority 2 Water System Improvements

Category	Improvements Description	Quantity	Unit
P	Pipeline Improvements for pressure deficiencies	0.4	miles
S	Storage Improvements	1.15	MG
PS	Pump Supply to Existing System	500	gpm
PR	Pump Replacement	7	Each

Priority 3 Potable Water System Improvements:

Table 7.1.3: Summary of Priority 3 Water System Improvements

Category	Improvements Description	Quantity	Unit
SD	Pipeline with a diameter less than 6-inches	9.5	miles

Cost Estimates for Capital Improvement Projects

An industry standard cost estimation methodology was developed to determine the capital improvements cost estimates. This method does not consider items such as utility relocation and right-of-way acquisition. This creates a baseline to compare and prioritize system improvement recommendations presented by the City of Kyle to those presented in this report. The costs presented in the report are based on **Table 7.1.4** and are calculated using 2015 dollars. It should be noted that the total cost values in **Appendix F** include a contingency of 30 percent for engineering costs and construction.

The cost matrix is based on an open cut installation method for implementing the recommended pipe capacity improvements and was developed using publicly available information. If another method of installation is to be implemented, such as boring, tunneling, other trenchless methods, the estimated cost should be modified to compensate for the cost of the selected construction method.

Table 7.1.4 illustrates the unit costs used to perform cost quantity takeoffs in estimating total costs. Unit costs are based on regional cost data from the City of Kyle for smaller pipe construction costs and the City of Austin for larger pipe construction costs. The approximate footage of ground cover (pavement or natural ground) was estimated using 2014 aerial photographs.

The estimated cost for each individual improvement project discussed in this report is summarized in **Appendix F**. Costs are broken down into estimated construction cost, estimated engineering cost, 15% construction contingency, and the total estimated cost. Total

pipe footages are estimated from GIS data. The number of valves and hydrants are estimated by placing a hydrant every 400 feet of pipe and placing valve every 250 feet of pipe.

These improvements are the results of engineering analysis of the model results and not necessarily the results of any particular design criteria analysis. The recommendations are designed to improve the performance of the water distribution system.

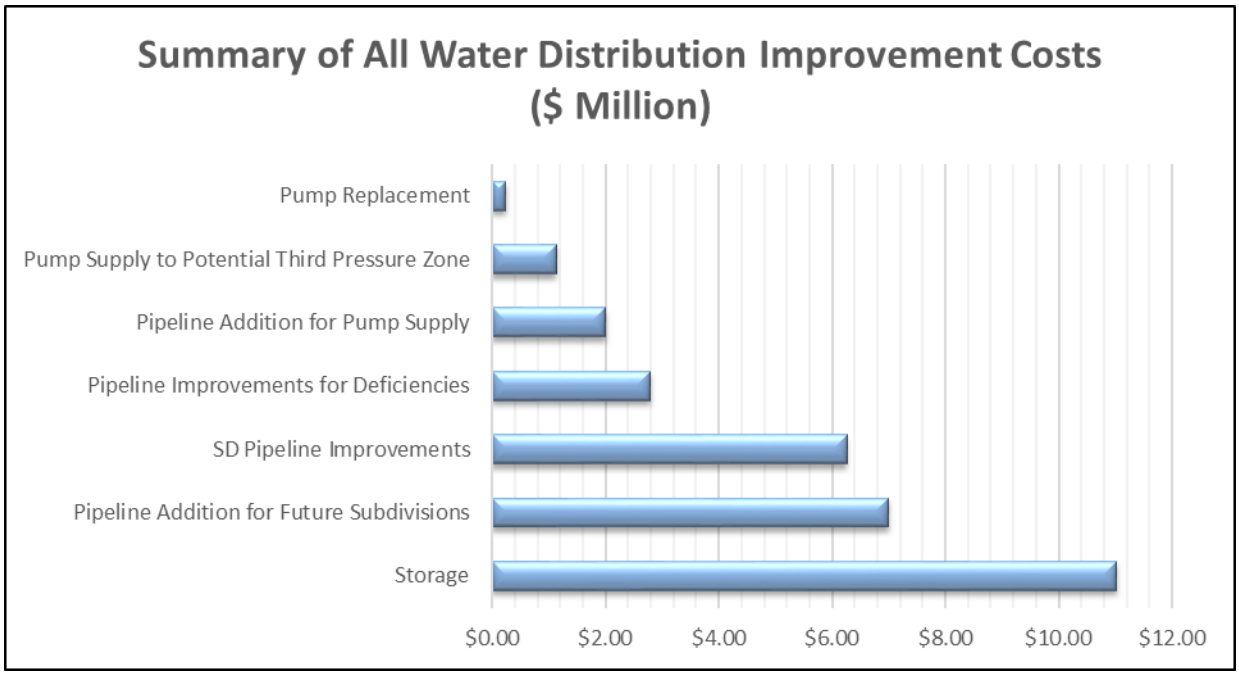
Table 7.1.4 Capital Improvement Projects Unit Costs

Description	Unit	Unit Price
Hot Mix Asphalt Concrete Pavement	SF	$18.00
Native Grassland Seeding and Planting	SY	$3.50
Pipe, 6" Dia., PVC Type (All Depths) Including Excavation and Backfill	LF	$75.00
Pipe, 8" Dia., PVC Type (All Depths) Including Excavation and Backfill	LF	$80.00
Pipe, 10" Dia., PVC Type (All Depths) Including Excavation and Backfill	LF	$85.00
Pipe, 12" Dia., PVC Type (All Depths) Including Excavation and Backfill	LF	$95.00
Pipe, 16" Dia., PVC Type (All Depths) Including Excavation and Backfill	LF	$120.00
Fire Hydrant Assembly, Including Excavation and Backfill	EACH	$5,000.00
Gate Valve Assembly, Including Excavation and Backfill	EACH	$2,000.00
Elevated Water Utility Storage Tank[1]	$/MG	$2,556,000.00
Pump Station[2]	$/MGD capacity	$350,000.00
Pump Replacement[3]	EACH	$15,000

1. Cost assumption assumes a steel tank.
2. Cost assumption assumes transmission pipelines, valves, and pumps.
3. Cost estimate from recent B&N pump replacement project.

The cost of the potable water CIP is estimated by project for all priority water system improvements and is presented in **Table 7.1.5** and **Figure 7.1.1.**

Table 7.1.5: Summary of All Water System Improvement Costs	
Facility Type	2015 ($ Million)
Priority 1 Water System Improvements	
Pipeline Improvements for Deficiencies	2.3
Pipeline Addition for Future Subdivisions	7.0
Pipeline Addition for Pump Supply	1.7
Pump Replacement	0.1
Pump Supply from High Pressure Zone to Potential Third Pressure Zone	1.1
Storage	7.1
Subtotal	**19**
Priority 2 Water System Improvements	
Pipeline Improvements for Deficiencies	0.4
Pump Replacement	0.1
Pump Supply to Existing System	0.3
Storage	3.9
Subtotal	**4.7**
Priority 3 Water System Improvements	
SD Pipeline Improvements	6.3
Subtotal	**6.3**
Total	**30.5**



Phasing of Improvements

Pipeline improvement deficiency projects are ranked by priority groups, with Priority 1 being the highest priority group.

Priority 1: Water Distribution System Improvements

The following projects have been identified as Priority 1 improvements: **Priority 1: Water Distribution System Improvements City of Kyle Water Distribution System** map is provided in **Appendix H** and is listed as follows:

Pipeline Improvements for fire flow deficiencies (FF)

- West Blanco Street

Pipeline Improvements for headloss and velocity deficiencies (HV)

- Well 2 transmission main
- Lehman transmission main
- South Old Stagecoach road

Pipeline addition for future subdivisions (FS)

- Anthem
- Aztec
- Blanco River Ranch
- Crosswinds MUD
- La Salle MUD
- Pecan Woods

Storage Improvements (S) – The preliminary location of the third pressure zone tank is discussed in **Section 6.2**.

- Third Pressure Zone Storage (2.11 MG)

Pipeline added for Pump Supply (PPS)

- Third Pressure Zone Supply Pipeline

Pump Replacement (PR) – Pumps with metered flows plus or minus 20 percent from the factory pump curve best efficiency point have been identified.

- Lehman (2 Pumps)
- Yarrington (3 Pumps)

Priority 2: Water Distribution System Improvements

Priority 2: Water Distribution System Improvements City of Kyle Water Distribution System map is provided in **Appendix H** and is listed as follows:

Pipeline Improvements for pressure deficiencies (P)

- Opal Lane

Storage Improvements (S) – The location of the additional storage tank in the low pressure zone has not yet been determined; therefore it is not shown in **Appendix H**.

- Low Pressure Zone Storage (1.15 MG)

Pump Supply (PS) – It is recommended that a minimum of additional 500 gpm water source be provided in order to supply the entire system at MDD with the largest source out of service in the year 2035 (based on average metered flow pump capacities). The location of the pump supply has not yet been determined; therefore it is not shown in **Appendix H.**

Pump Replacement (PR) – Pumps with metered flows plus or minus 10 percent from the factory pump curve best efficiency point have been identified.

- Well 3 (1 Pump)
- Well 5 (1 Pump)
- Rebel Road Service (3 Pumps)
- 1626 (2 Pumps)

Priority 3: Water Distribution System Improvements

Priority 3: Water Distribution System Improvements City of Kyle Water Distribution System map is provided in **Appendix H** and is listed as follows:

SD Pipeline Improvements: Small diameter pipeline replacement can occur at any period of time form 2021-2035. There is no fire flow deficiency with the existing small diameter pipe identified; however, replacing small diameter pipeline will improve hydraulic performance throughout the system.

Appendix A

Appendix A - References

City of Kyle. 2015. *Closed Valve-City of Kyle Notes.*

City of Kyle. August 2008. *Elevations of Water Storage Tanks.*

City of Kyle. 2015. *High Pressure Plane (#2) to Low Pressure Plane (#1) connecting valves (normally closed).*

City of Kyle. 2014. *Water System Summary Water Model RFQ.*

City of Kyle. February 2009. *Water System Schematic.*

American Water Works Association. 2005. *Computer Modeling of Water Distribution Systems – AWWA Manual M32 Second Edition*, AWWA, Denver, CO.

American Water Works Association and American Water Works Association Research Foundation. 1992. *Water Industry Database: Utility Profiles*. Denver, Colo.: AWWA.

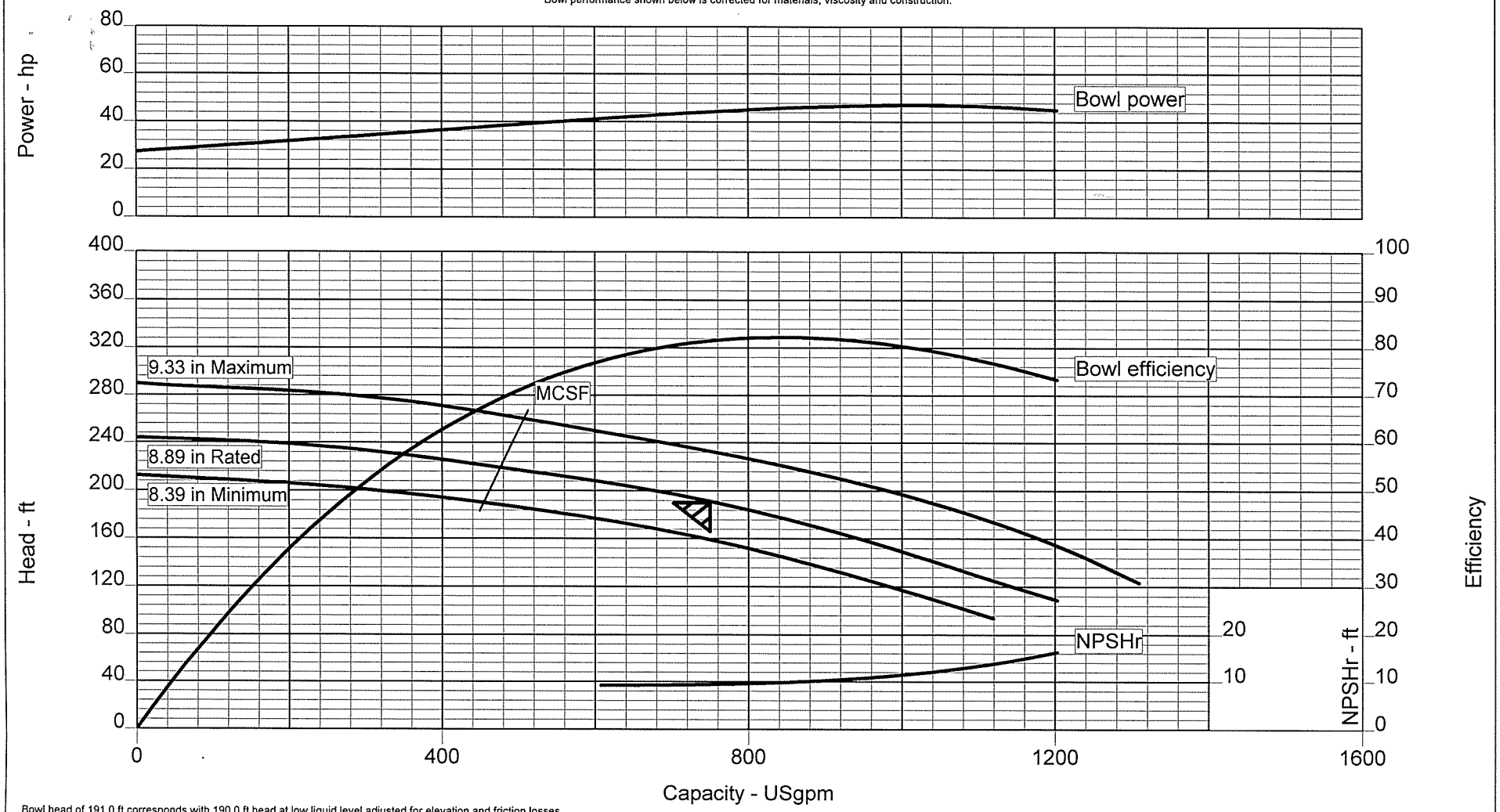
Appendix B

Lehman and 1626 Pumps

Customer	:	FLOWSERVE Pump Division		Pump size & type	: 12EMM
Item number	: SH00851			Based on curve no.	: EC-2633
Service	:			Number of stages	: 3
Vendor reference	: 4844-W0000	Capacity	: 750.0 USgpm	Specific gravity	: 0.999
Date	: August 14, 2007	Head	: 190.00 ft	Pump speed	: 1770 rpm

CURVES ARE APPROXIMATE, PUMP IS GUARANTEED FOR ONE SET OF CONDITIONS, CAPACITY, HEAD, AND EFFICIENCY.

Bowl performance shown below is corrected for materials, viscosity and construction.



Bowl head of 191.0 ft corresponds with 190.0 ft head at low liquid level adjusted for elevation and friction losses.

WinPROS+ V3.2.3

RUHRPUMPEN

Global Proposal System 14.4.1.0

Pump Performance Datasheet

Customer	:	Quote number	:
Customer reference	:	Size	: 12B-90
Item number	: Default	Stages	: 2
Service	:	Based on curve number	: VTP-12B-90-1760
Quantity	: 1	Date last saved	: 12/04/2014 9:41 AM

Operating Conditions

Flow, rated	: 750.0 USgpm
Differential head / pressure, rated (requested)	: 140.0 ft
Differential head / pressure, rated (actual)	: 141.1 ft
Suction pressure, rated / max	: 0.00 / 0.00 psi.g
NPSH available, rated	: Ample
Frequency	: 60 Hz

Performance

Speed, rated	: 1,760 rpm
Impeller diameter, rated	: 8.50 in
Impeller diameter, maximum	: 8.56 in
Impeller diameter, minimum	: 7.50 in
Efficiency (bowl / pump)	: 80.9 / - %
NPSH required / margin required	: 10.91 / 2.00 ft
Ns (imp. eye flow) / Nss (imp. eye flow)	: 2,215 / 8,100 US Units
MCSF	: 262.7 USgpm
Head, maximum, rated diameter	: 172.3 ft
Head rise to shutoff	: 23.41 %
Flow, best eff. point (BEP)	: 874.4 USgpm
Flow ratio (rated / BEP)	: 85.78 %
Diameter ratio (rated / max)	: 99.28 %
Head ratio (rated dia / max dia)	: 95.56 %
Cq/Ch/Ce/Cn [ANSI/HI 9.6.7-2010]	: 1.00 / 1.00 / 1.00 / 1.00
Selection status	: Acceptable

Liquid

Liquid type	: Chemical
Additional liquid description	:
Solids diameter, max	: 0.00 in
Solids concentration, by volume	: 0.00 %
Temperature, max	: 68.00 deg F
Fluid density, rated / max	: 1.000 / 1.000 SG
Viscosity, rated	: 1.00 cP
Vapor pressure, rated	: 0.00 psi.a

Material

Material selected	: Cast iron, bronze fitted

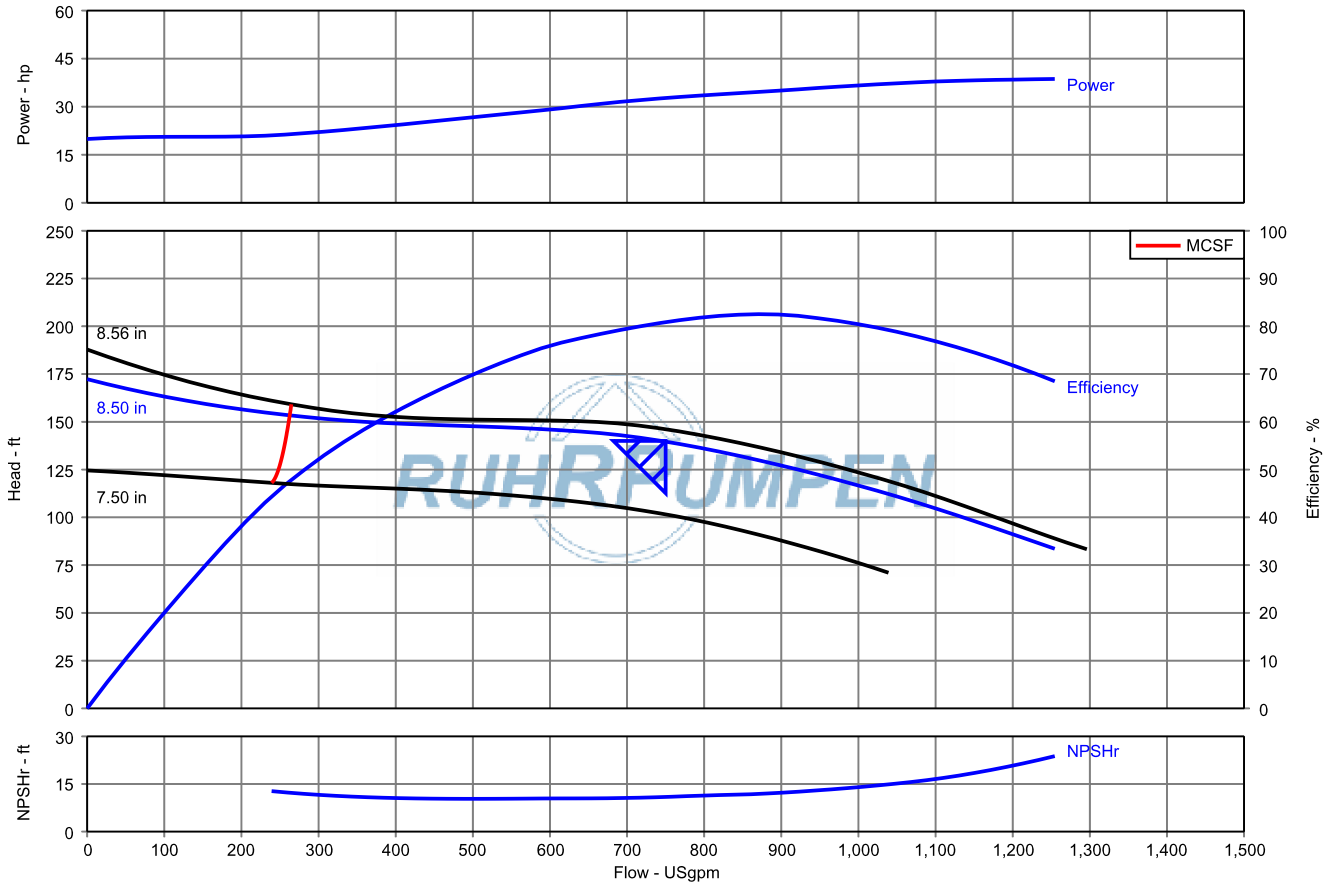
Pressure Data

Maximum discharge pressure	: See the Additional Data page
Maximum allowable working pressure	: See the Additional Data page
Maximum allowable suction pressure	: N/A
Hydrostatic test pressure	: See the Additional Data page

Driver & Power Data

Driver sizing specification	: Rated power
Margin over specification	: 0.00 %
Service factor	: 1.00
Power, hydraulic	: 26.45 hp
Power (bowl / pump)	: 32.71 / -
Power, maximum, rated diameter	: 38.65 hp
Minimum recommended motor rating	: 40.00 hp / 29.83 kW

Pump performance. Adjusted for construction, viscosity, friction and power losses of lineshaft and thrust bearings. Not adjusted for any static lift.
The duty point represents the head at the bowl.



Rebel Road Service Pumps

Model: VIS-T	Size: 7CSHC	60Hz	RPM: 3489	Stages: 5

Job/Inq.No. : KUTCHER C-C
Purchaser : AUSTIN PUMP & SUPPLY CO

End User : AUSTIN PUMP & SUPPLY CO
Item/Equip.No. : ITEM 001
Order No. :

Issued by : Ricky Schoor
Quotation No. : RS14-09-03 02
Certified By :

Service :
Date : 09/04/2014
Rev. : 0

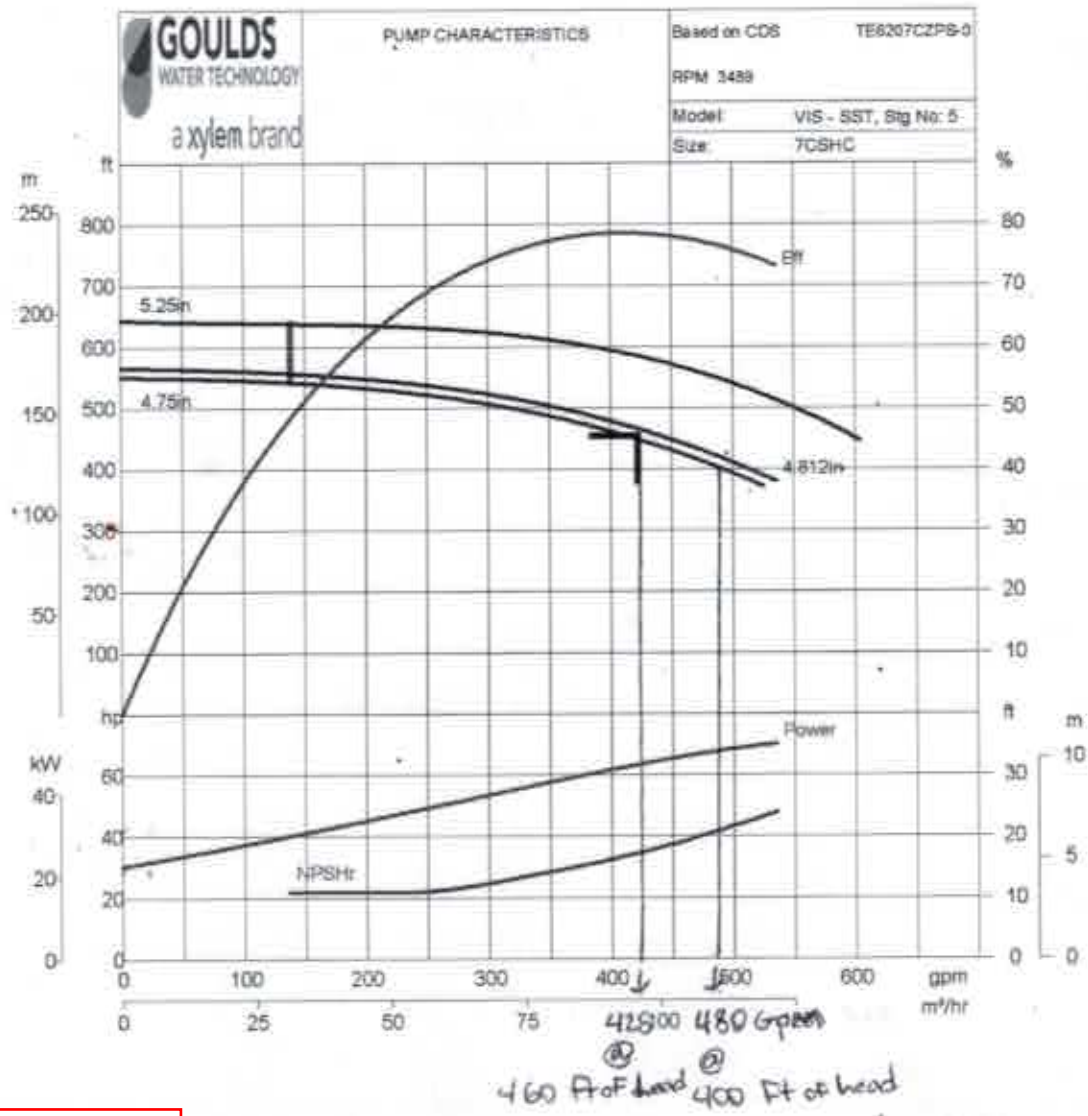
Operating Conditions

Temp.:	70.0 deg F
Design Flow:	425.0 gpm
Design TDH:	460.0 ft
Actual Flow:	425.0 gpm
Actual Bowl Head:	464.4 ft
NPSHa:	
Solid size:	
Bowl Size:	7.1300 in
Liquid:	
S.G./Visc.:	1.000/1.000 cp

Pump Performance

Bowl Efficiency:	79.0 %	Suction Specific Speed:	8,088 gpm(US) ft
Rated Pump Efficiency:	78.4 %	Min. Hydraulic Flow:	137.0 gpm
Rated Total Power:	63.54 hp	Min. Thermal Flow:	N/A
Non-Overloading Power:	70.2 hp (@ R.O. Flow: 535.4 gpm)		
Imp. Dia. First 1 Stg(s):	4.8125 in	Imp. Dia. Addt'l Stg(s):	4.8125 in
NPSHr:	17.4 ft	Vapor Press:	
Shut off Head:	565.9 ft	Max. Solids Size:	0.0000 in
Max. Lateral:	0.5000 in	Thrust K factor:	3.50
Bowl Material:	316SS		
Impeller Material:	316SS		

Notes:
1. Bowl Performance Curve based on Pumping Clear, non-Aerated Water. Rated Point only is guaranteed.
2. For units requiring performance test, all performance tests will be conducted per ANSI/HI 14.6 standards unless otherwise noted in the selection software submittal documents. Test results meeting with grade 2B tolerances for pumps with a rated shaft power of 134HP or less and grade 1B for greater than 134HP will be considered passing.



Well 3 Pump

Customer : Odessa Pumps - Odessa TX - (Fairbanks)

Pump Performance Datasheet

Encompass 2.0 - 14.4.1.0

Item number	: 97/E-17402	Size	: 360 - 4x4x7A
Service	:	Stages	: 1
Quantity	: 1	Based on curve number	: 43-4x4x7A-3500 Rev 0
Quote number	: BUDGET	Date last saved	: 02 Dec 2014 10:03 AM

Operating Conditions

Flow, rated	: 500.0 USgpm
Differential head / pressure, rated (requested)	: 100.0 ft
Differential head / pressure, rated (actual)	: 100.4 ft
Suction pressure, rated / max	: 0.00 / 0.00 psi.g
NPSH available, rated	: Ample
Frequency	: 60 Hz

Performance

Speed, rated	: 3,500 rpm
Impeller diameter, rated	: 6.19 in
Impeller diameter, maximum	: 6.75 in
Impeller diameter, minimum	: 4.88 in
Efficiency	: 78.53 %
NPSH required / margin required	: 15.50 / 0.00 ft
Ns (imp. eye flow) / Nss (imp. eye flow)	: 2,712 / 9,200 US Units
Minimum Continuous Stable Flow	: 181.0 USgpm
Head, maximum, rated diameter	: 142.1 ft
Head rise to shutoff	: 42.42 %
Flow, best eff. point (BEP)	: 592.2 USgpm
Flow ratio (rated / BEP)	: 84.43 %
Diameter ratio (rated / max)	: 91.67 %
Head ratio (rated dia / max dia)	: 78.75 %
Cq/Ch/Ce/Cn [ANSI/HI 9.6.7-2010]	: 1.00 / 1.00 / 1.00 / 1.00
Selection status	: Acceptable

Liquid

Liquid type	: Water
Additional liquid description	:
Solids diameter, max	: 0.00 in
Solids concentration, by volume	: 0.00 %
Temperature, max	: 68.00 deg F
Fluid density, rated / max	: 0.999 / 0.999 SG
Viscosity, rated	: 1.00 cP
Vapor pressure, rated	: 0.34 psi.a

Material

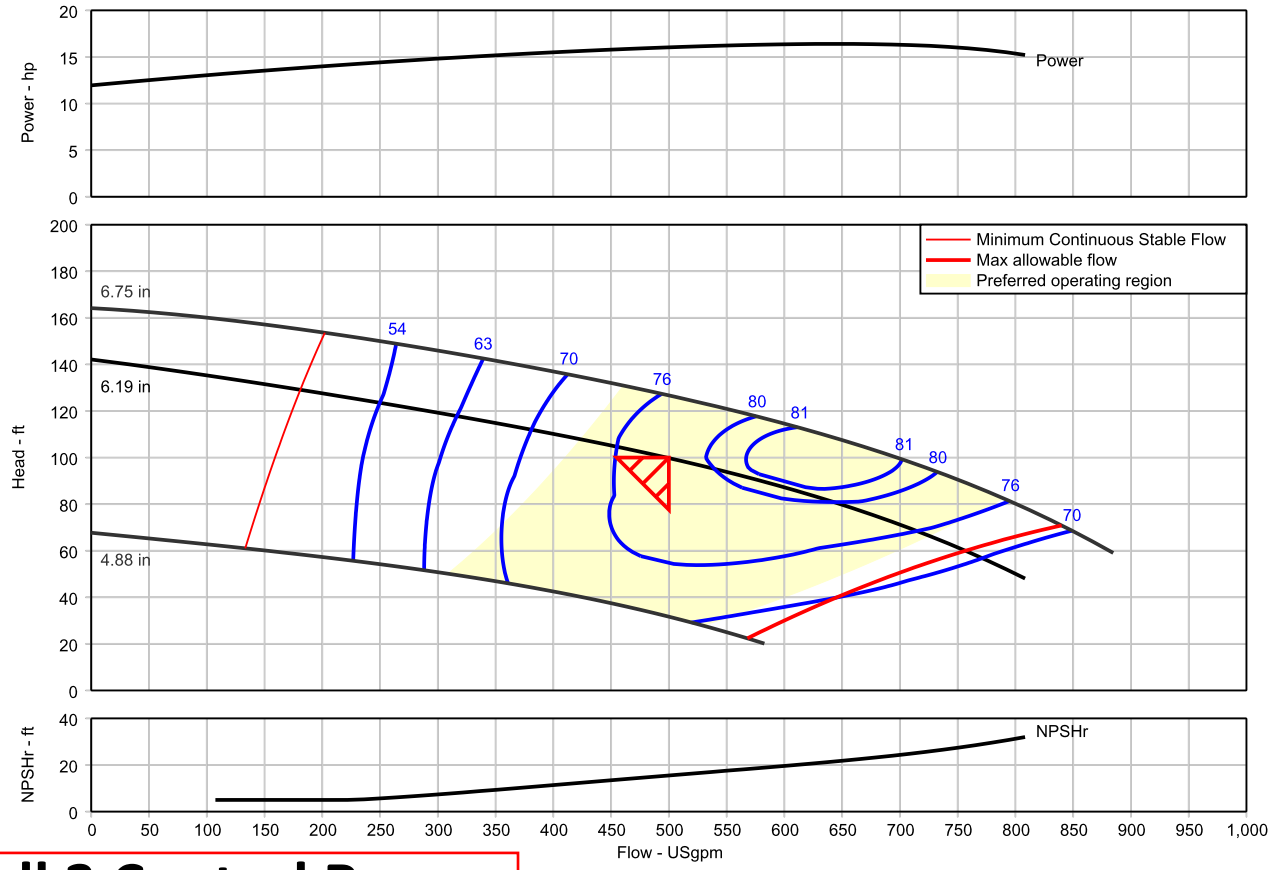
Material selected	: Standard

Pressure Data

Maximum working pressure	: 61.48 psi.g
Maximum allowable working pressure	: 175.0 psi.g
Maximum allowable suction pressure	: 175.0 psi.g
Hydrostatic test pressure	: 125.0 psi.g

Driver & Power Data

Driver sizing specification	: Max Power
Margin over specification	: 0.00 %
Service factor	: 1.00
Power, hydraulic	: 12.59 hp
Power, rated	: 16.03 hp
Power, maximum, rated diameter	: 16.40 hp
Minimum recommended motor rating	: 20.00 hp / 14.91 kW



Well 3 Control Room Service Pumps

Customer :
Project name :

Pump Performance Datasheet

Encompass 2.0 - 14.5.0.0

Item number	: Default	Size	: 12B-SS
Service	:	Stages	: 2
Quantity	: 1	Based on curve number	: 12_TURB_2200_1800_BR
Quote number	:	Date last saved	: 09 Feb 2015 10:13 AM

Operating Conditions

Flow, rated	: 1,000.0 USgpm
Differential head / pressure, rated (requested)	: 100.0 ft
Differential head / pressure, rated (actual)	: 100.00 ft
Suction pressure, rated / max	: 0.00 / 0.00 psi.g
NPSH available, rated	: Ample
Frequency	: 60 Hz

Performance

Speed, rated	: 1,770 rpm
Impeller diameter, rated	: 8.66 in
Impeller diameter, maximum	: 9.18 in
Impeller diameter, minimum	: 8.62 in
Efficiency (bowl / pump)	: 74.96 / 73.68 %
NPSH required / margin required	: 14.08 / 0.00 ft
nq (imp. eye flow) / S (imp. eye flow)	: 44 / 156 Metric units
Minimum Continuous Stable Flow	: 490.4 USgpm
Head, maximum, rated diameter	: 143.2 ft
Head rise to shutoff	: 41.29 %
Flow, best eff. point (BEP)	: 814.1 USgpm
Flow ratio (rated / BEP)	: 122.83 %
Diameter ratio (rated / max)	: 94.34 %
Head ratio (rated dia / max dia)	: 84.38 %
Cq/Ch/Ce/Cn [ANSI/HI 9.6.7-2010]	: 1.00 / 1.00 / 1.00 / 1.00
Selection status	: Acceptable

Liquid

Liquid type	: Water
Additional liquid description	:
Solids diameter, max	: 0.00 in
Solids concentration, by volume	: 0.00 %
Temperature, max	: 68.00 deg F
Fluid density, rated / max	: 0.999 / 0.999 SG
Viscosity, rated	: 1.00 cP
Vapor pressure, rated	: 0.34 psi.a

Material

Material selected	: Cast Iron / Bronze

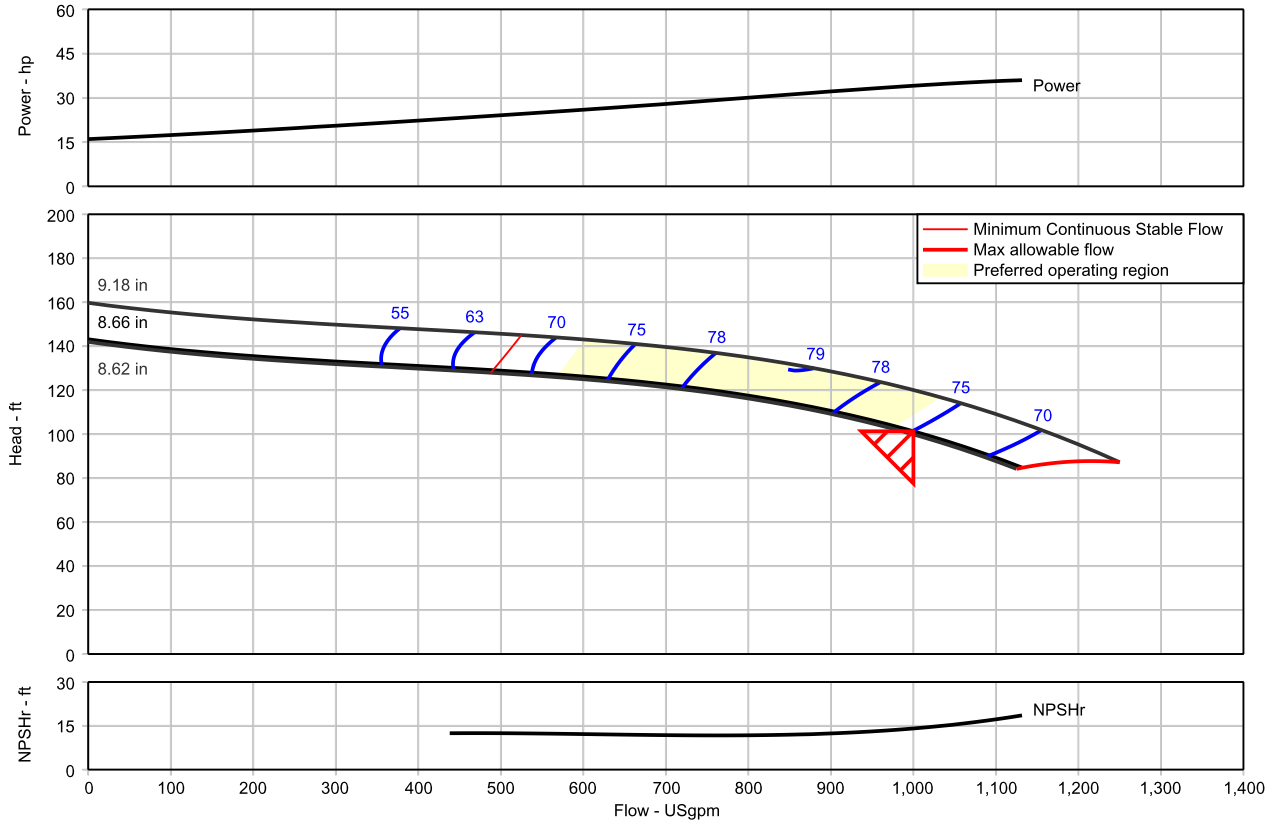
Pressure Data

Maximum working pressure	: See the Additional Data page
Maximum allowable working pressure	: See the Additional Data page
Maximum allowable suction pressure	: N/A
Hydrostatic test pressure	: See the Additional Data page

Driver & Power Data

Driver sizing specification	: Maximum power
Margin over specification	: 0.00 %
Service factor	: 1.00
Power, hydraulic	: 25.58 hp
Power (bowl / pump)	: 34.12 / 34.25 hp
Power, maximum, rated diameter	: 36.15 hp
Minimum recommended motor rating	: 40.00 hp / 29.83 kW

Bowl performance. Adjusted for construction and viscosity.
The duty point represents the head at the bowl.



Well 3 Outside Pump

FAIRBANKS NIJHUIS
3501 FAIRBANKS AVENUE · KANSAS CITY, KANSAS 66106
WWW.FAIRBANKSNIJHUIS.COM

PHONE: +1-913-371-5000 · FAX:

Company: Odessa Pumps
Name:
Date: 6/9/2015

Yarrington Pumps

Pump:

Size: 10-H-60 (6 stage)

Type: VERT.TURB.ENCLOSED
Synch speed: 1800 rpm

Speed: 1770 rpm
Dia: 7.75 in

Curve: CV10-H-604P6CY

Impeller: 10-H-60

Specific Speeds:

Ns: 2800
Nss: 8100

Dimensions:

Suction: ---
Discharge: ---

Vertical Turbine:

Bowl size: 9.8 in
Max lateral: 0.75 in
Thrust K factor: 6.6 lb/ft

Pump Limits:

Temperature: 180 °F
Pressure: 330 psi g
Sphere size: 0.61 in

Power: 284 hp
Eye area: 14.6 in²

Search Criteria:

Flow: 550 US gpm

Head: 231 ft

Fluid:

Water
SG: 1
Viscosity: 0.9946 cP

Temperature: 68 °F
Vapor pressure: 0.3391 psi a
Atm pressure: 14.7 psi a

NPSHa: ---

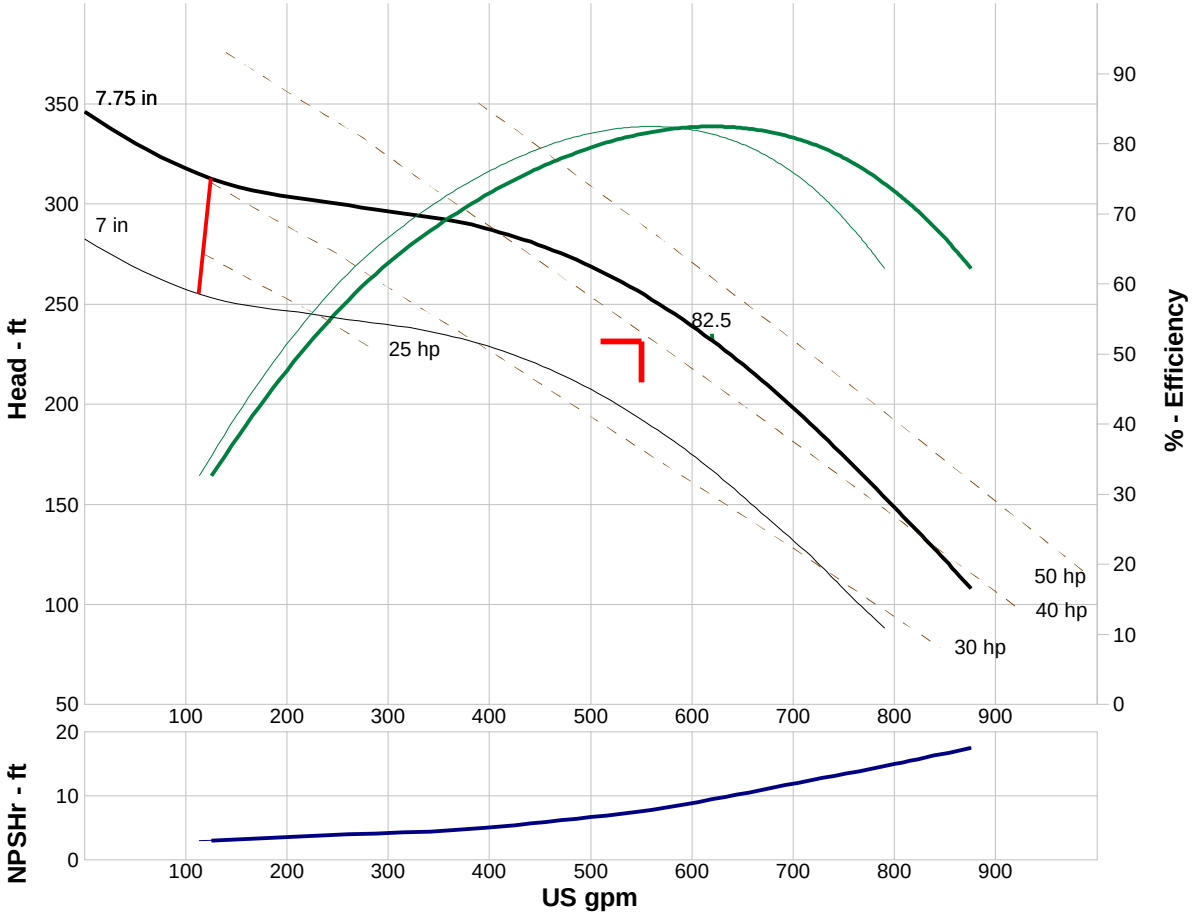
Motor:

Standard: NEMA
Enclosure: WP-I

Size: 50 hp
Speed: 1800
Frame: 326

Sizing criteria: Max Power on Design Curve

---- Data Point ----	
Flow:	550 US gpm
Head:	255 ft
Eff:	81.4%
Power:	43.5 hp
NPSHr:	7.63 ft
---- Design Curve ----	
Shutoff head:	346 ft
Shutoff dP:	150 psi
Min flow:	124 US gpm
BEP:	82.5% @ 620 US gpm
NOL power:	44 hp @ 620 US gpm
-- Max Curve --	
Max power:	44 hp @ 620 US gpm



NOTES (UNLESS OTHERWISE SPECIFIED): [1] PUMP LIMITS AND PERFORMANCE BASED ON STANDARD MATERIALS. [2] PERFORMANCE MEETS HI 14.6-2011 GRADE 1B TOLERANCES AT THE RATED CONDITION WITHIN THE SELECTION WINDOW. [3] NPSHR AT 1ST STAGE IMPELLER CENTERLINE.

Performance Evaluation:

Flow US gpm	Speed rpm	Head ft	Efficiency %	Power hp	NPSHr ft
660	1770	215	81.9	43.7	10.7
550	1770	255	81.4	43.5	7.63
440	1770	280	75.8	41	5.75
330	1770	293	65.4	36.9	4.52
220	1770	303	50.3	32.9	3.7

RECEIVED

OCT 1 2006

Hydroflo pumps

Company: FRIEDEL DRILLING COMPANY
Name: CITY OF KYLE WELL #2
Date: 10/16/2006

Pump:
Size: 12CX (6 stage)
Type: Vertical
Synch speed: 1760 rpm
Curve: 12CX
Specific Speeds:
Dimensions:
Vertical Turbine

Speed: 1760 rpm
Dia: 9.15 in
Impeller:
Ns: 1760
Nss: —
Section: 6 in
Discharge: 6 in
Bowl size: 11.625 in
Max lateral: 0.812 in
Thrust K factor: 5 lb/ft

Pump Limits:
Temperature: 140 °F
Pressure: 254 psi g
Sphere size: 0.655 in

Power: 250 hp
Eye area: — in²

Search Criteria:
Flow: 550 US gpm
Head: 372 ft

Fluid:
Water
Density: 62.25 lb/ft³
Viscosity: 1.105 cP
NPSHa: -- ft

Temperature: 80 °F
Vapor pressure: 0.2563 psi a
Atm pressure: 14.7 psi a

Motor:
Standard: NEMA
Enclosure: TEFC

— hp
Speed: —
Frame: —

Sizing criteria: Max Power on Design Curve

— Data Point —

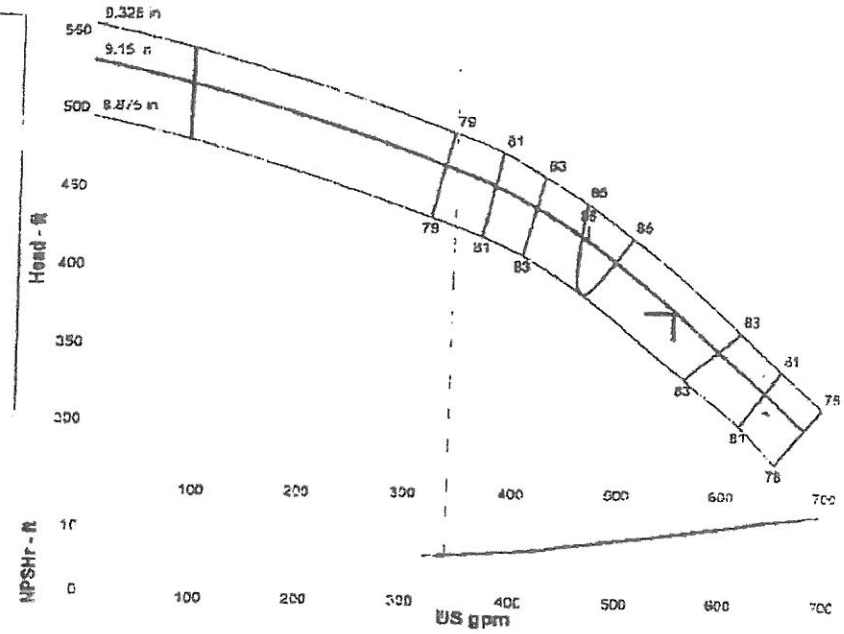
Flow	550 US gpm
Head	373 ft
Eff	83.9%
Power	61.3 hp
NPSHr	9.64 ft

--- Design Curve ---

Shutoff head	632 ft
Shutoff dP	230 psi
Min flow	93.2 US gpm
BEP	85% @ 466 US gpm
NOL power	65.4 hp @ 578 US gpm

-- Max Curve --

Max power	70.2 hp @ 695 US gpm



Performance Evaluation:

Flow US gpm	Speed rpm	Head ft	Efficiency %	Power hp	NPSHr ft
660	1760	309	79.4	64.8	12
550	1760	373	83.9	61.3	9.64
440	1760	429	84.1	56.7	7.4
330	1760	466	75.9	49.2	5.93
220	1760	498	74.1	39.5	4.61

GAP-FLO 9

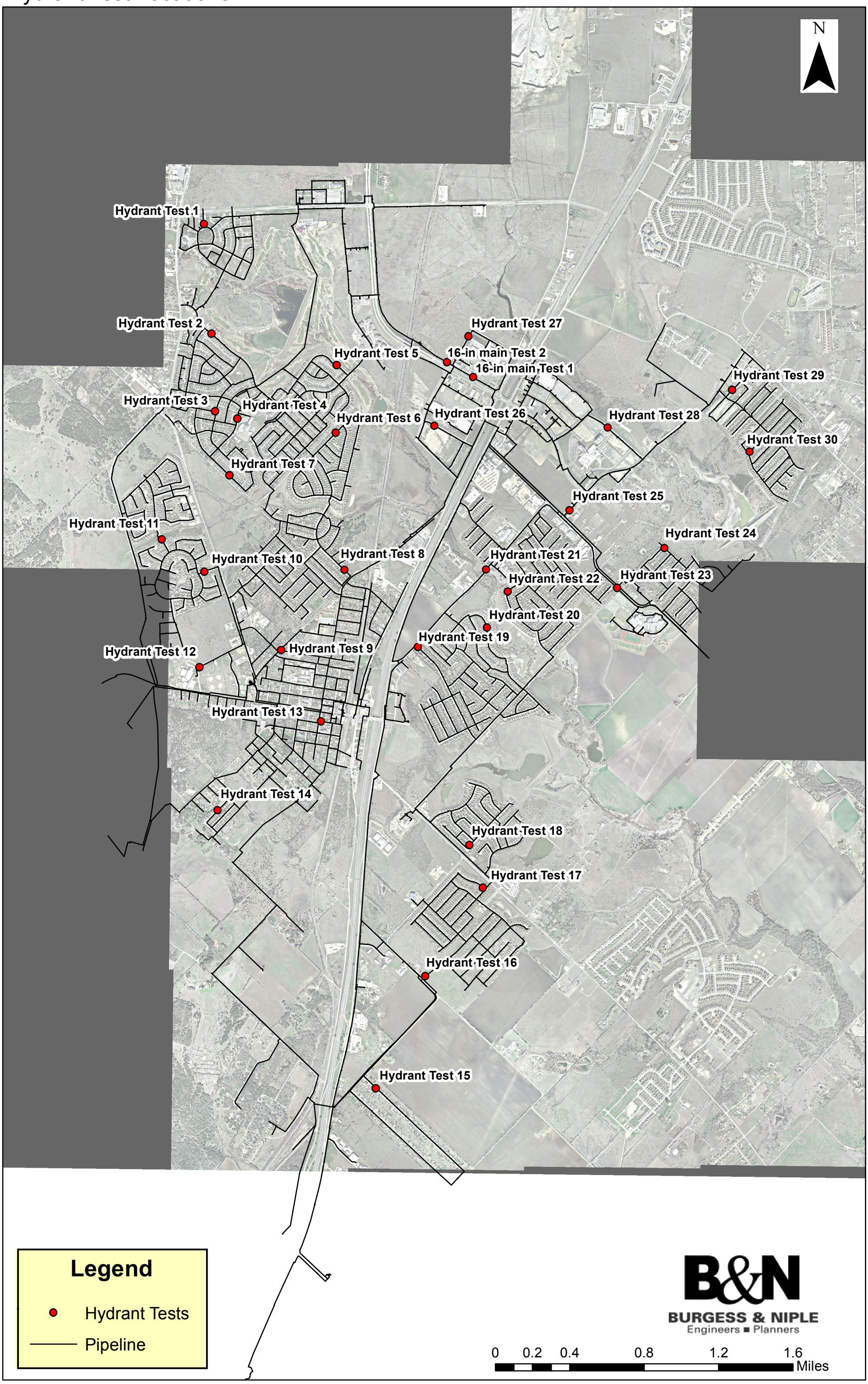
* Selected from catalog. Hydroflo V&S Pumps 60Hz Vers

OCT-19-2006 10:04AM FROM-FRIEDEL DRILLING COMPANY 361 293 7085 T-617 P.003/003 F-457

Well 2 Pump

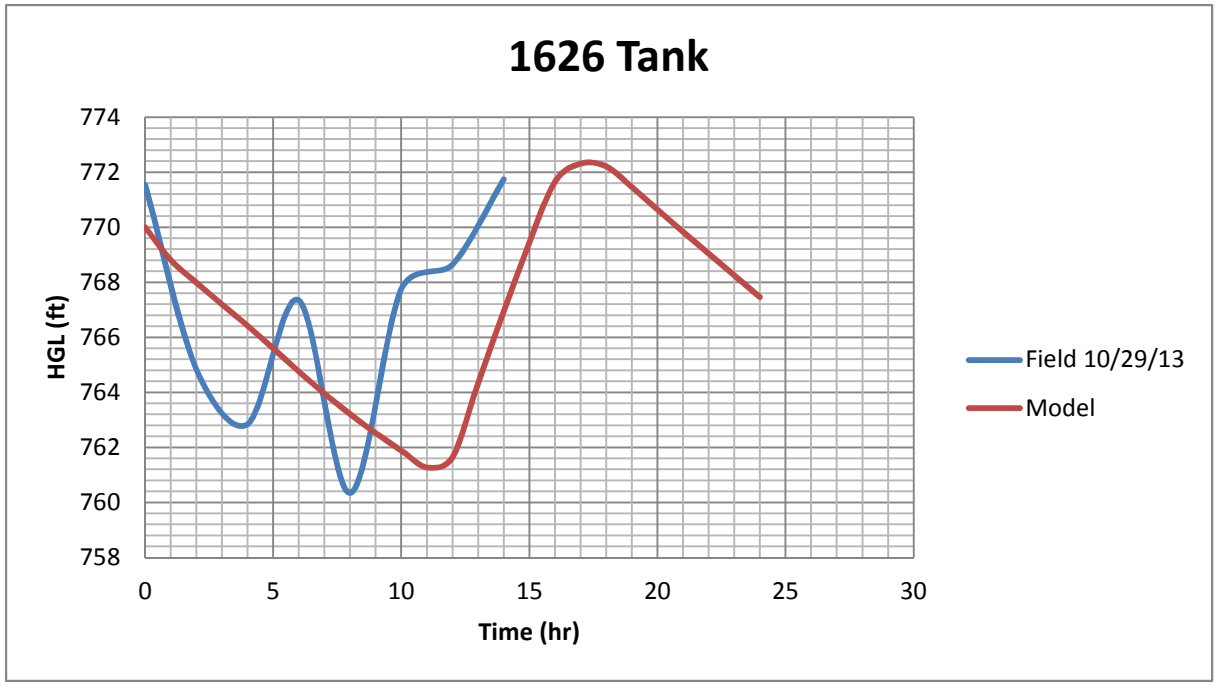
Appendix C

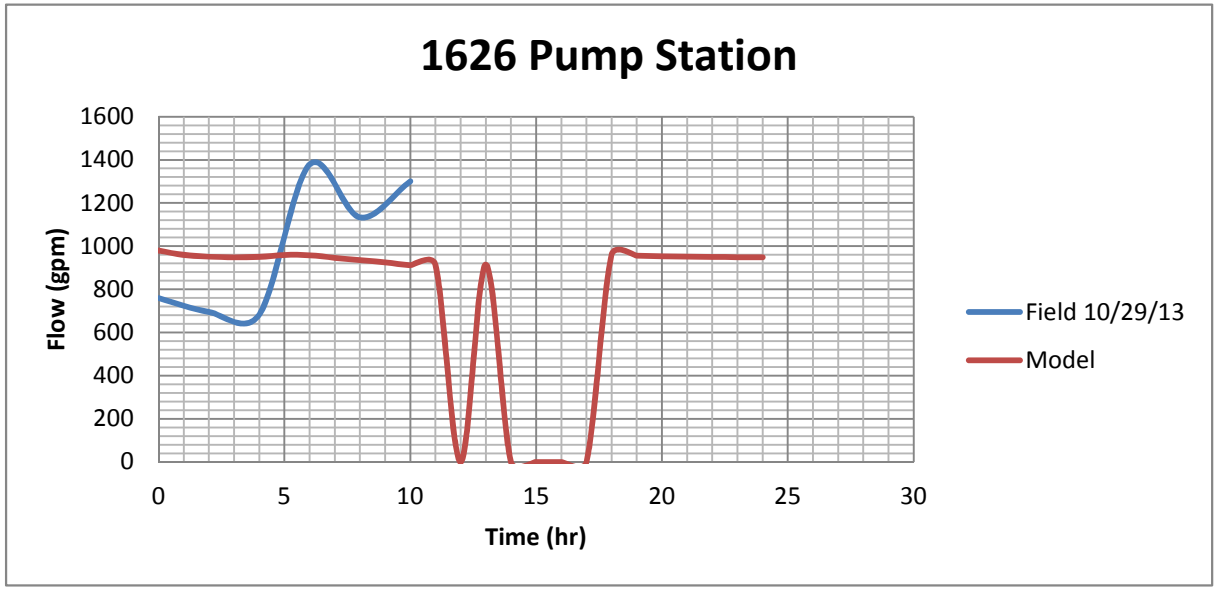
City of Kyle Water Distribution Model
Hydrant Test Locations

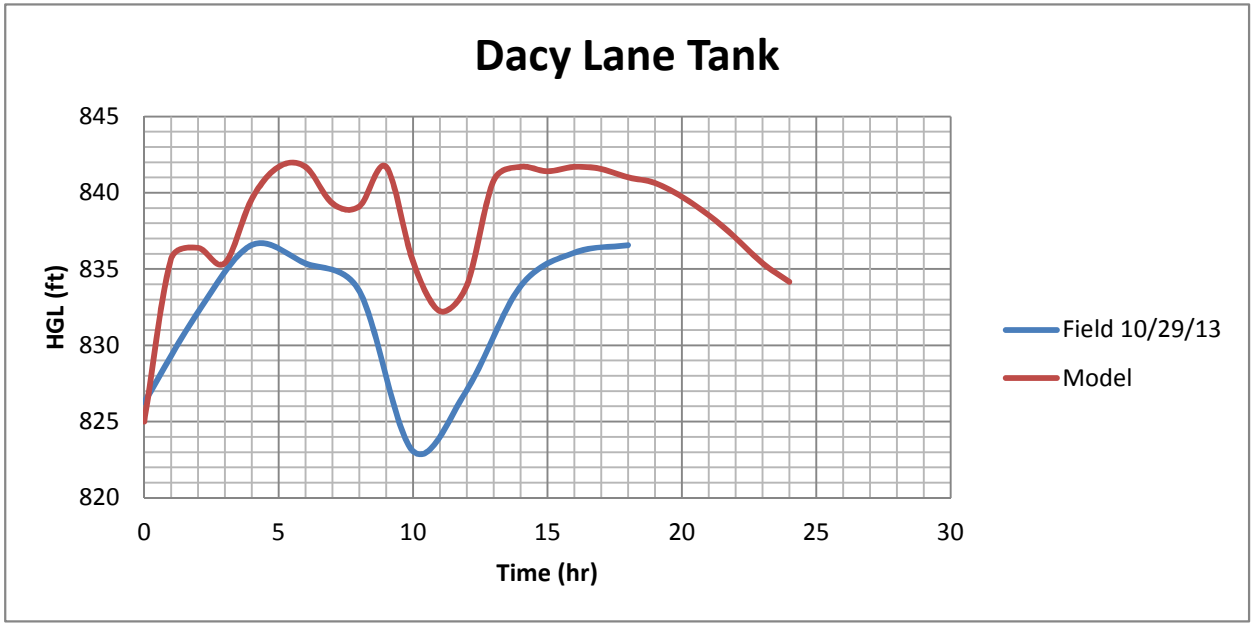


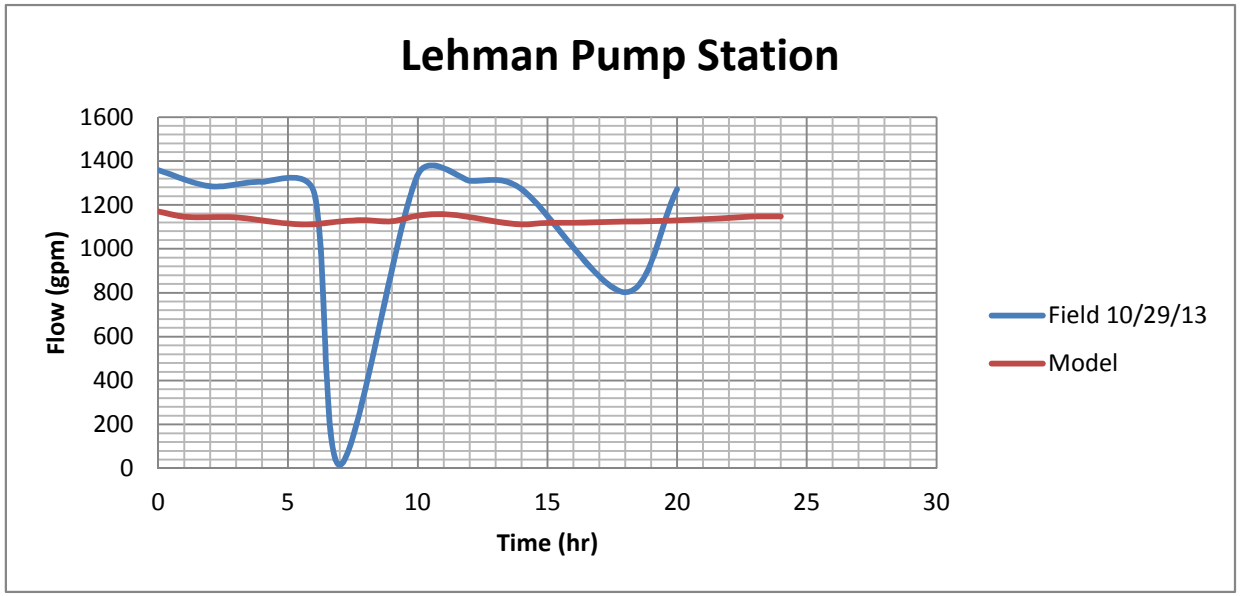
City of Kyle Water Distribution Model
Hydrant Test Locations Out of Tolerance

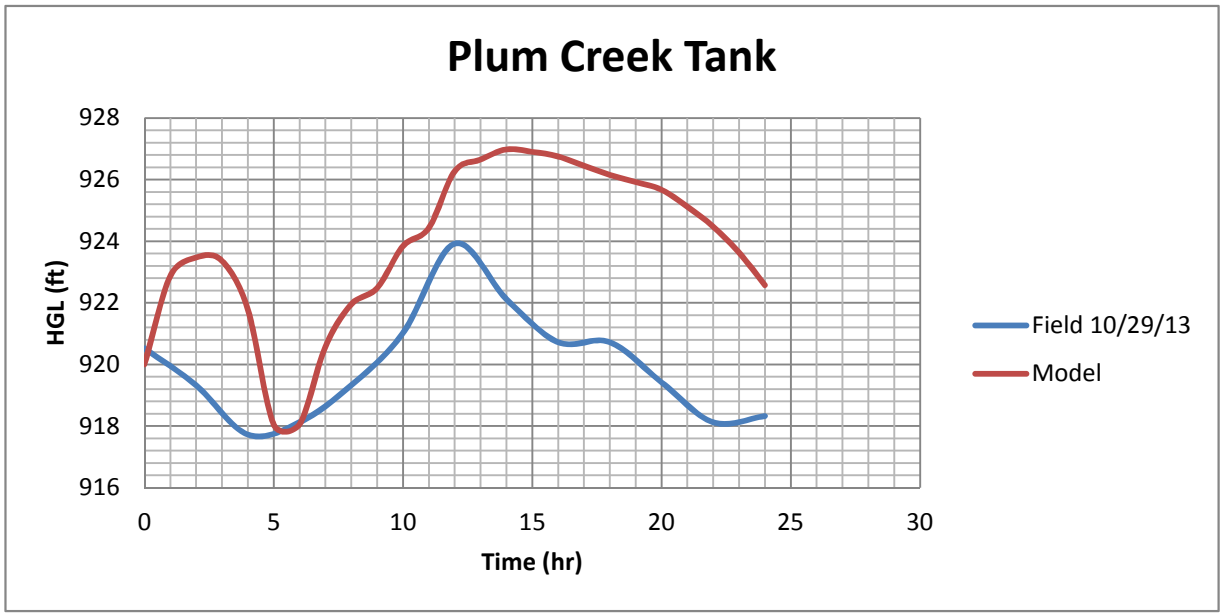
Appendix D

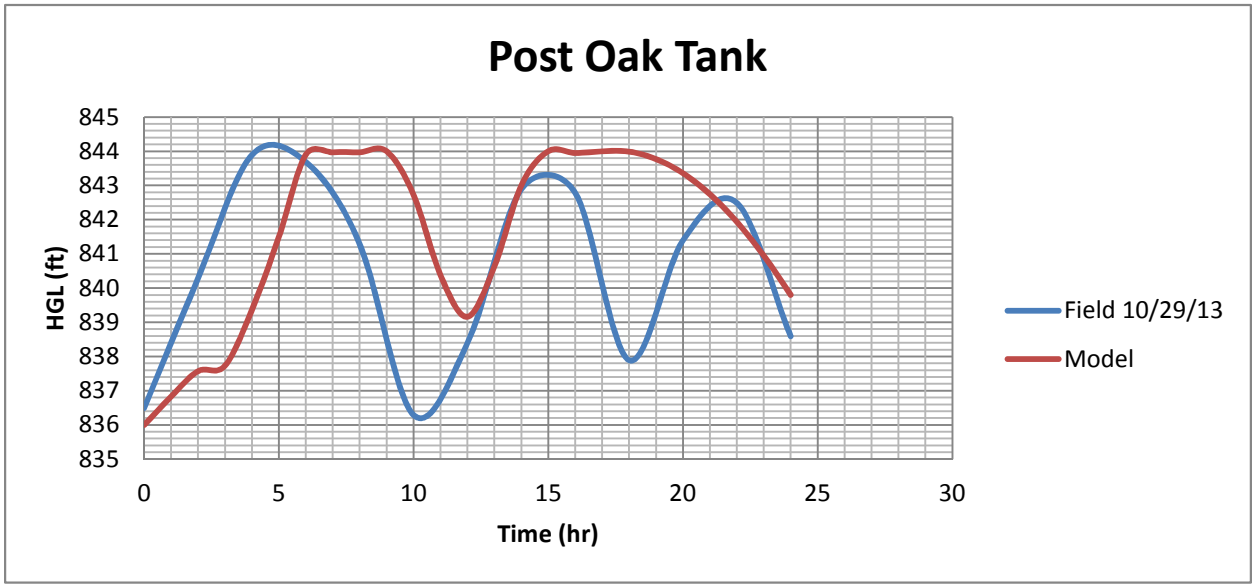

1626 Tank
774
772
770
768
766
764
762
760
758
HGL (ft)
0
5
10
15
20
25
30
Time (hr)
Field 10/29/13
Model

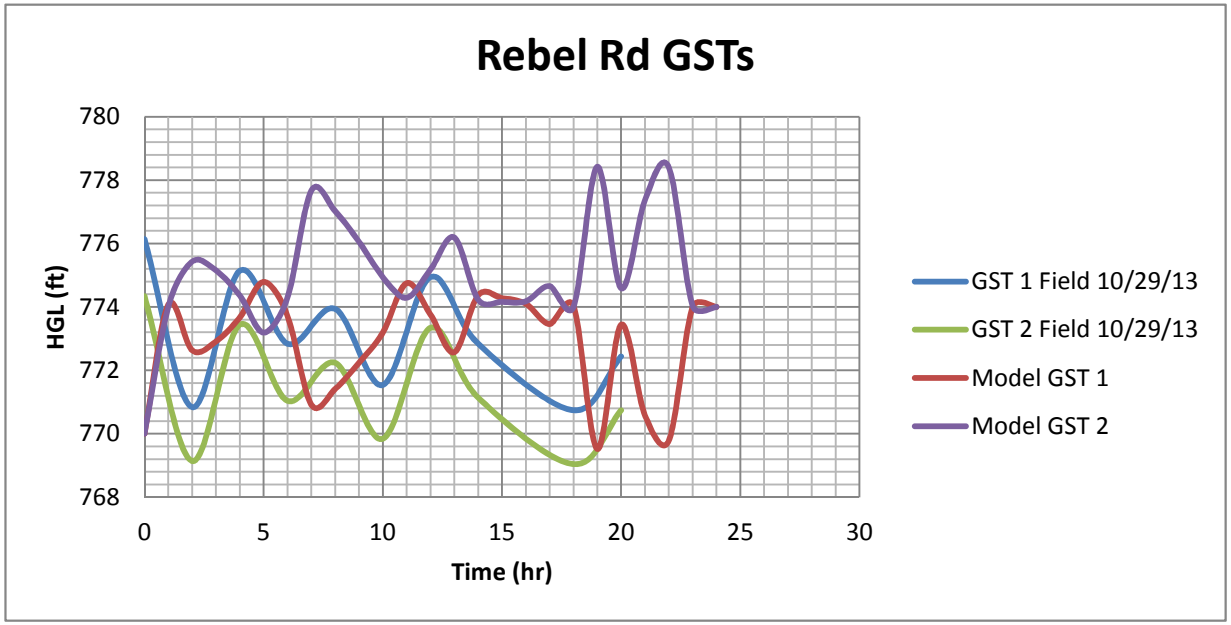

1626 Pump Station
1600
1400
1200
1000
800
600
400
200
0
Flow (gpm)
0
5
10
15
20
25
30
Time (hr)
Field 10/29/13
Model

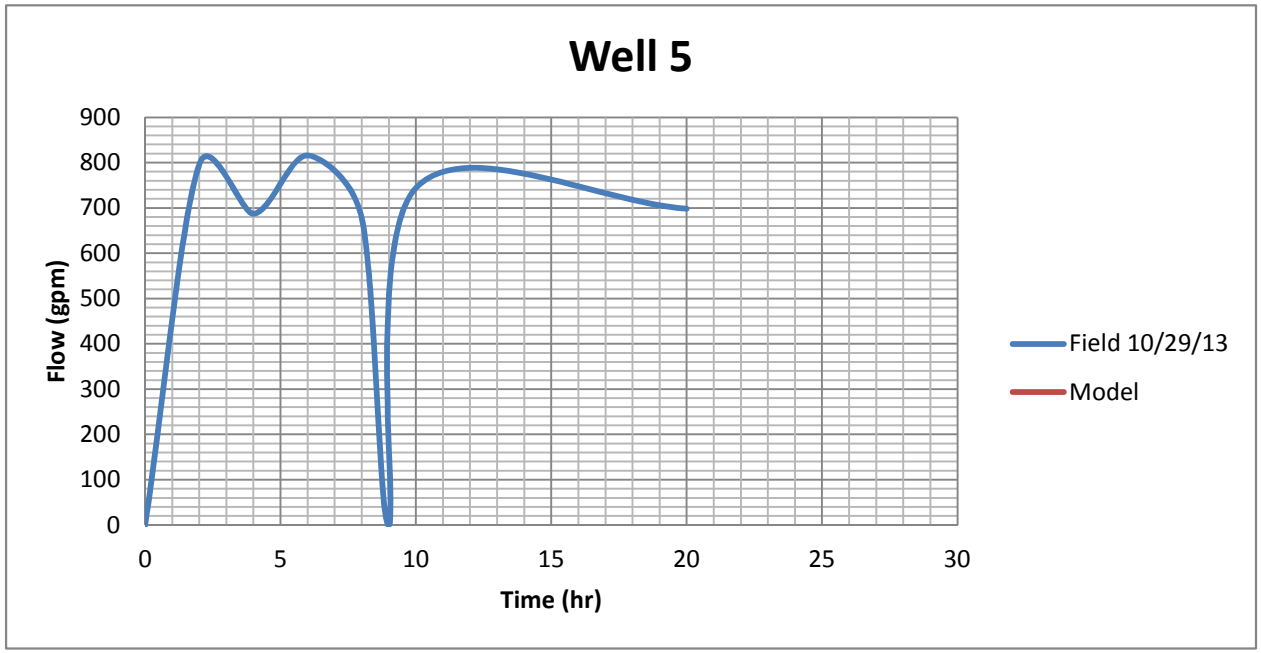

Dacy Lane Tank
845
840
835
830
825
820
HGL (ft)
0
5
10
15
20
25
30
Time (hr)
Field 10/29/13
Model

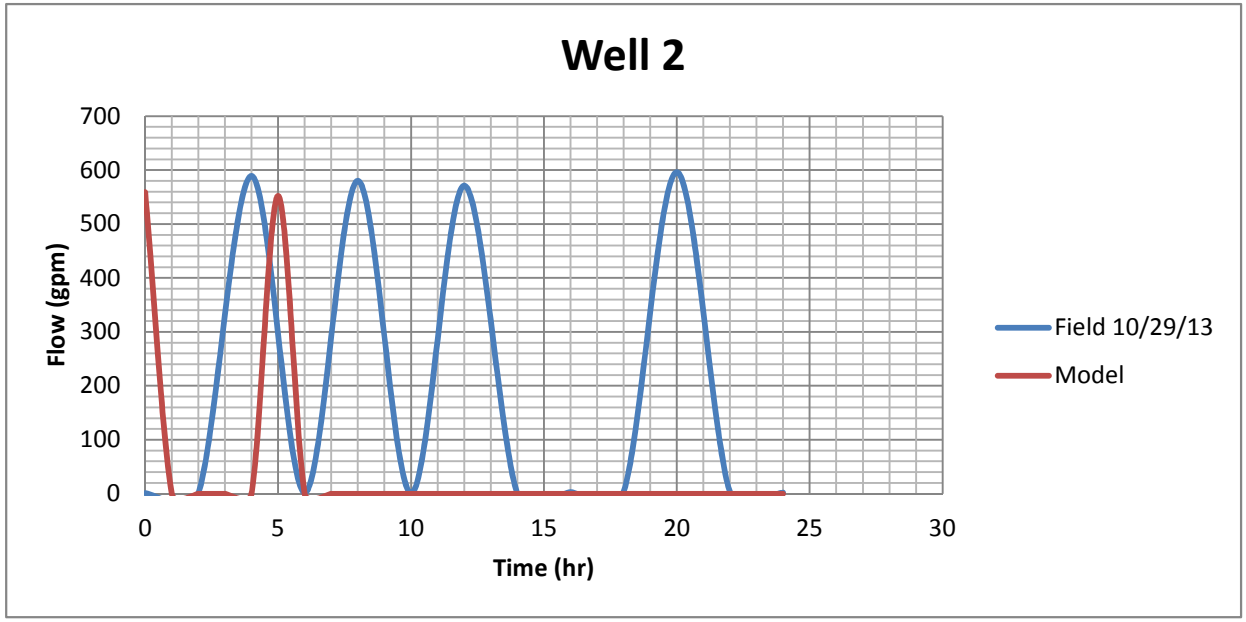

Lehman Pump Station
1600
1400
1200
1000
800
600
400
200
0
Flow (gpm)
0
5
10
15
20
25
30
Time (hr)
Field 10/29/13
Model

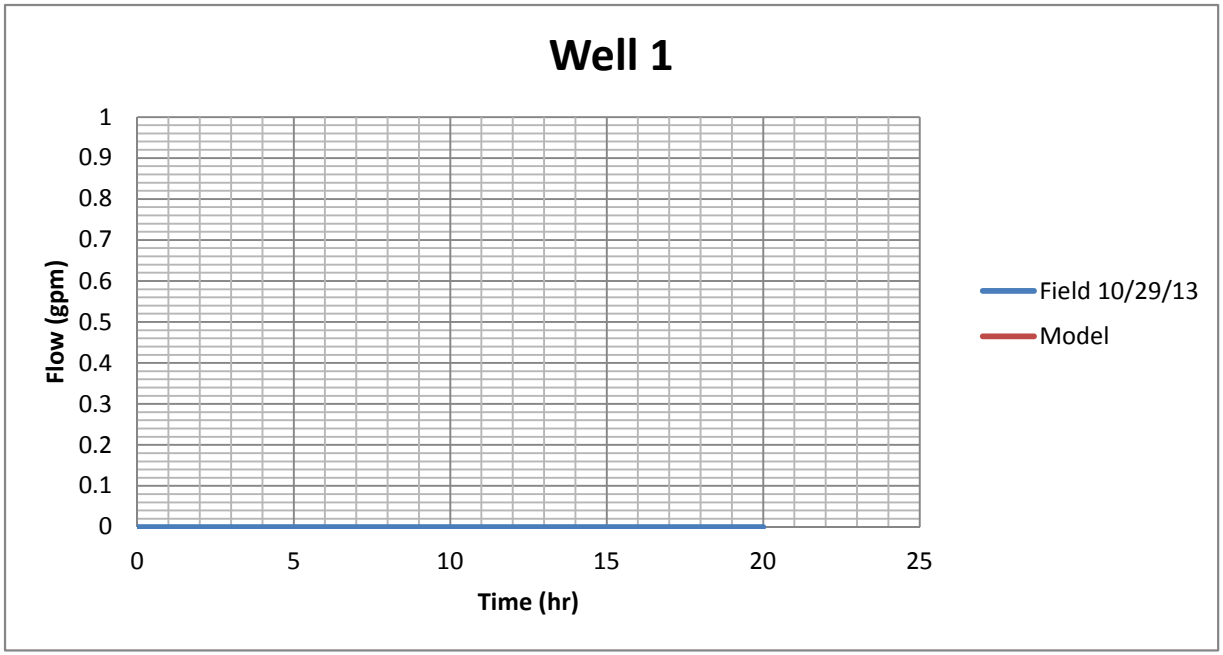

Plum Creek Tank
928
926
924
922
920
918
916
HGL (ft)
0
5
10
15
20
25
30
Time (hr)
Field 10/29/13
Model

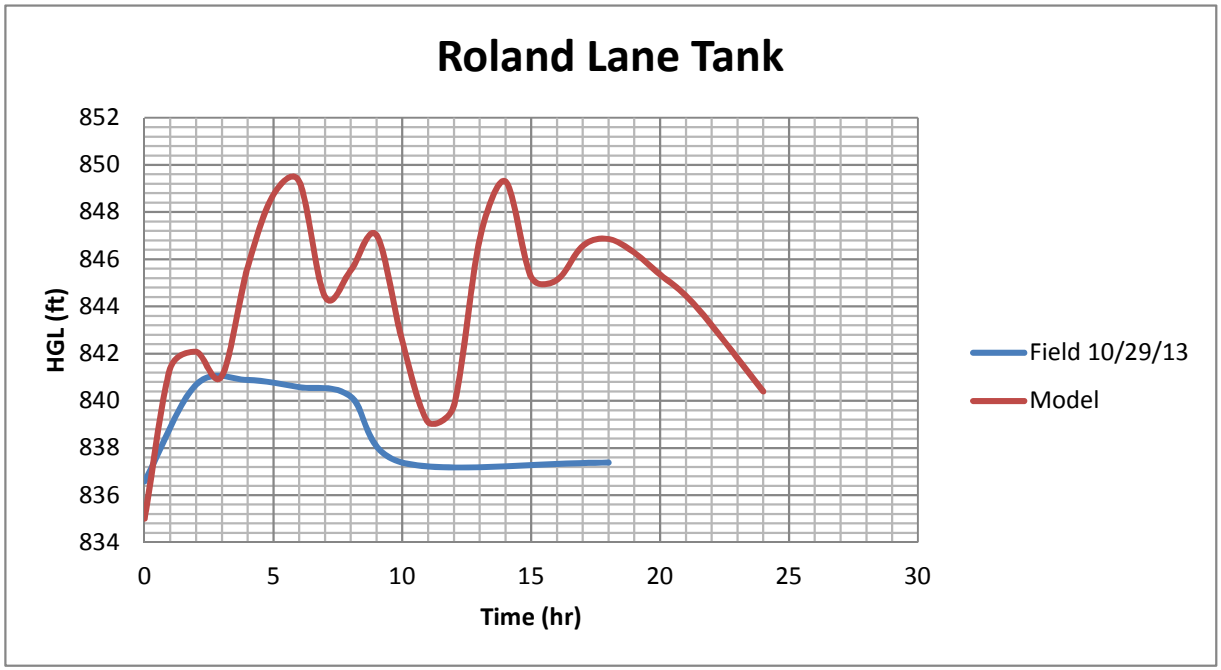

Post Oak Tank
845
844
843
842
841
840
839
838
837
836
835
HGL (ft)
0
5
10
15
20
25
30
Time (hr)
Field 10/29/13
Model

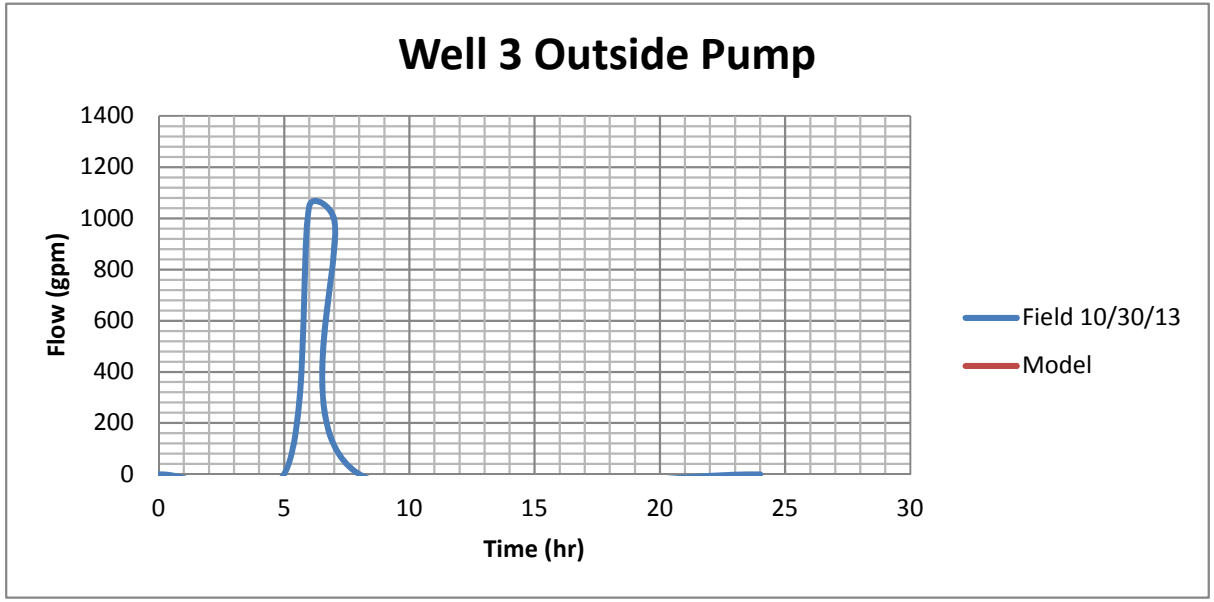

Rebel Rd GSTs
780
778
776
774
772
770
768
HGL (ft)
0
5
10
15
20
25
30
Time (hr)
GST 1 Field 10/29/13
GST 2 Field 10/29/13
Model GST 1
Model GST 2

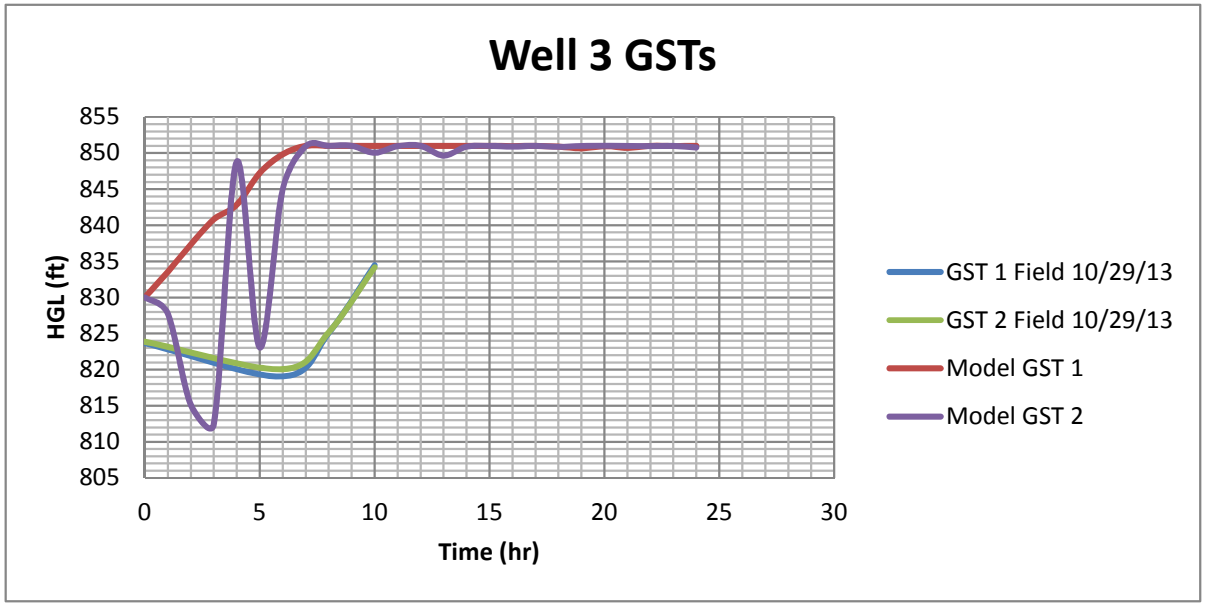

Well 5
900
800
700
600
500
400
300
200
100
0
Flow (gpm)
0
5
10
15
20
25
30
Time (hr)
Field 10/29/13
Model

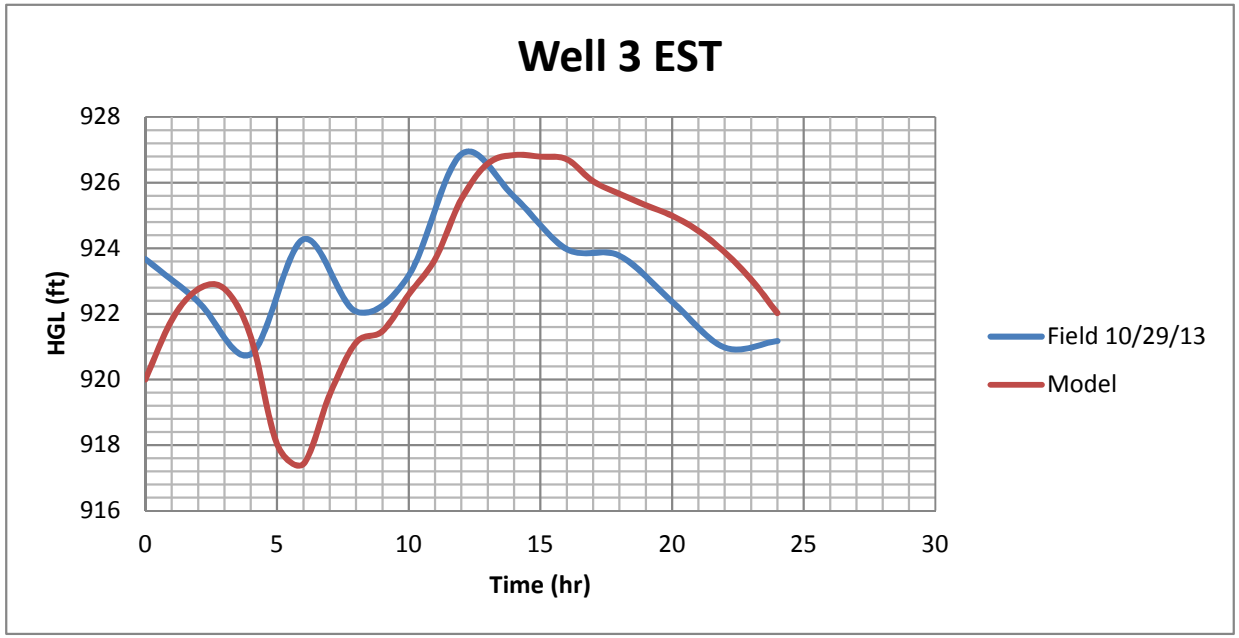

Well 2
700
600
500
400
300
200
100
0
Flow (gpm)
0
5
10
15
20
25
30
Time (hr)
Field 10/29/13
Model

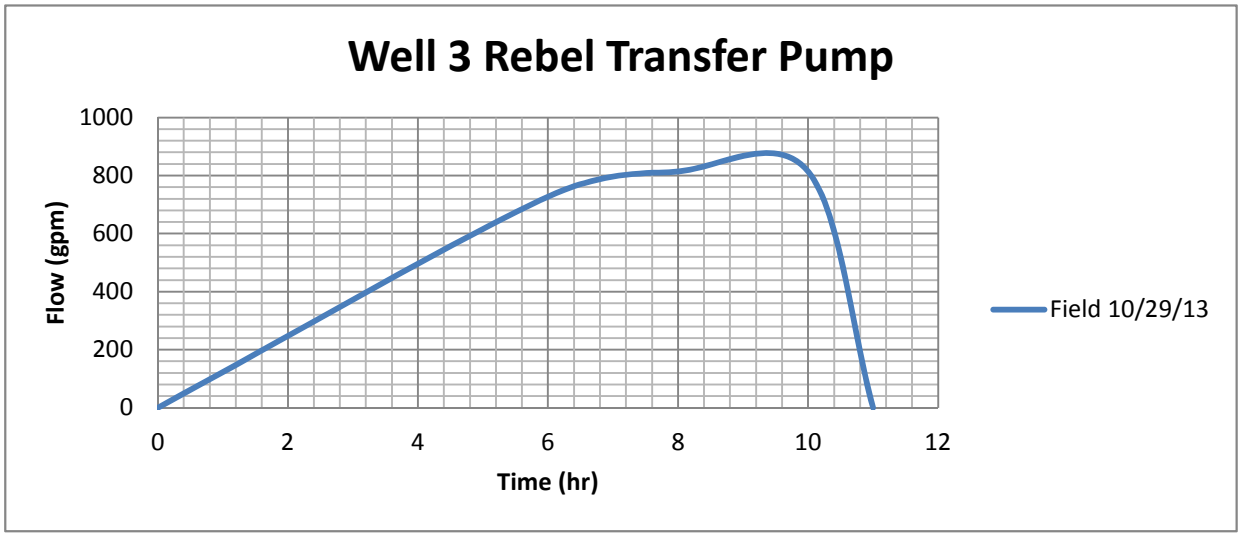

Well 1
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
Flow (gpm)
0
5
10
15
20
25
Time (hr)
Field 10/29/13
Model

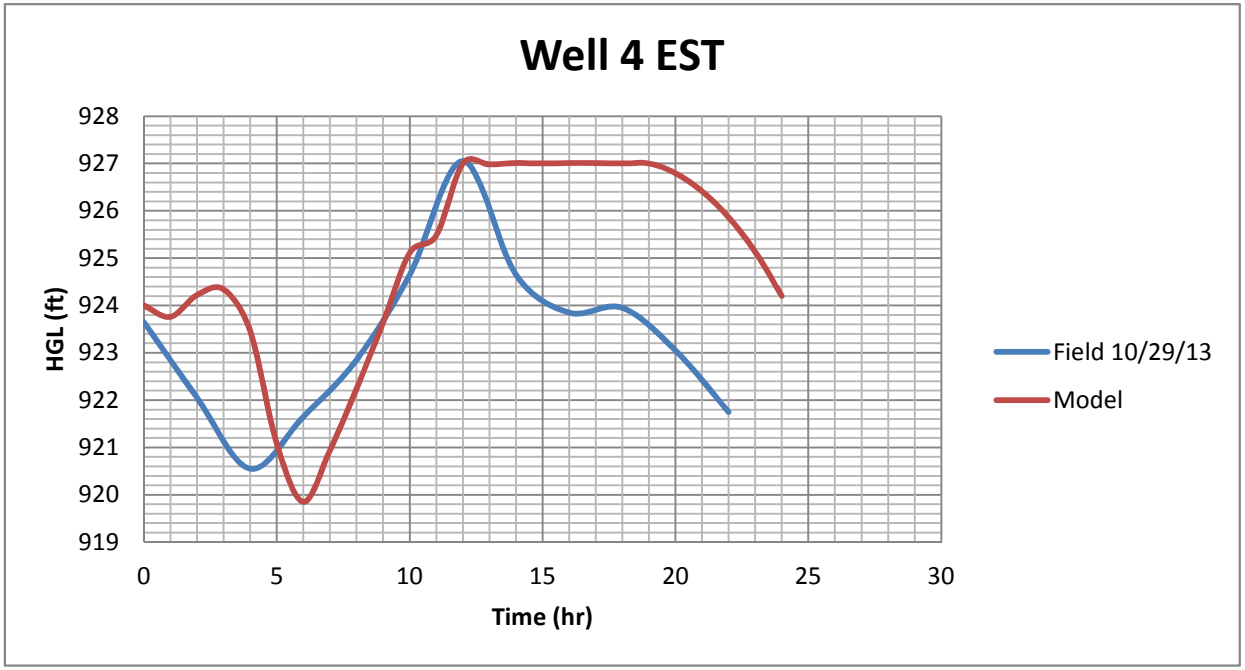

Roland Lane Tank
852
850
848
846
844
842
840
838
836
834
HGL (ft)
0
5
10
15
20
25
30
Time (hr)
Field 10/29/13
Model

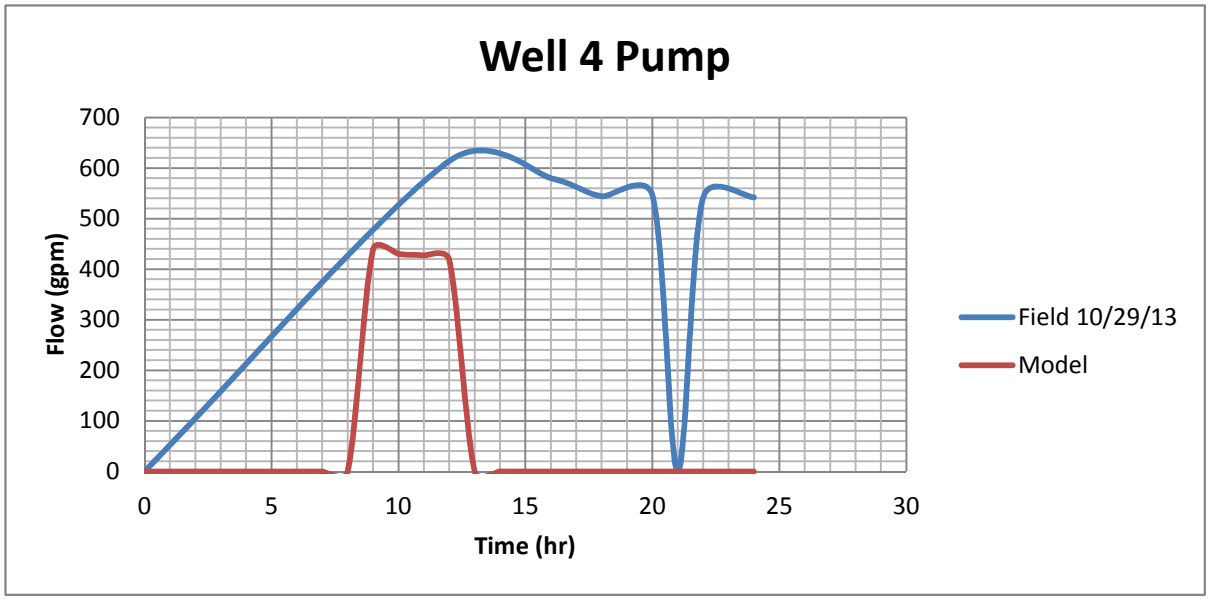

Well 3 Outside Pump
1400
1200
1000
800
600
400
200
0
Flow (gpm)
0
5
10
15
20
25
30
Time (hr)
Field 10/30/13
Model

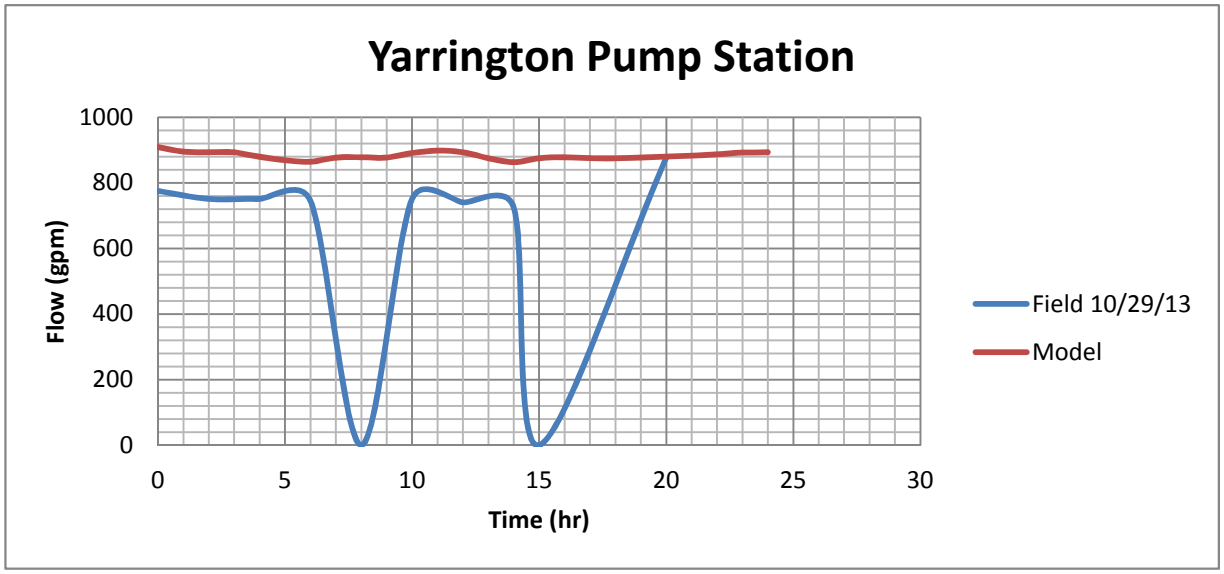

Well 3 GSTs
HGL (ft)
855
850
845
840
835
830
825
820
815
810
805
0
5
10
15
20
25
30
Time (hr)
GST 1 Field 10/29/13
GST 2 Field 10/29/13
Model GST 1
Model GST 2


Well 3 EST
HGL (ft)
928
926
924
922
920
918
916
0
5
10
15
20
25
30
Time (hr)
Field 10/29/13
Model


Well 3 Rebel Transfer Pump
Flow (gpm)
1000
800
600
400
200
0
0
2
4
6
8
10
12
Time (hr)
Field 10/29/13

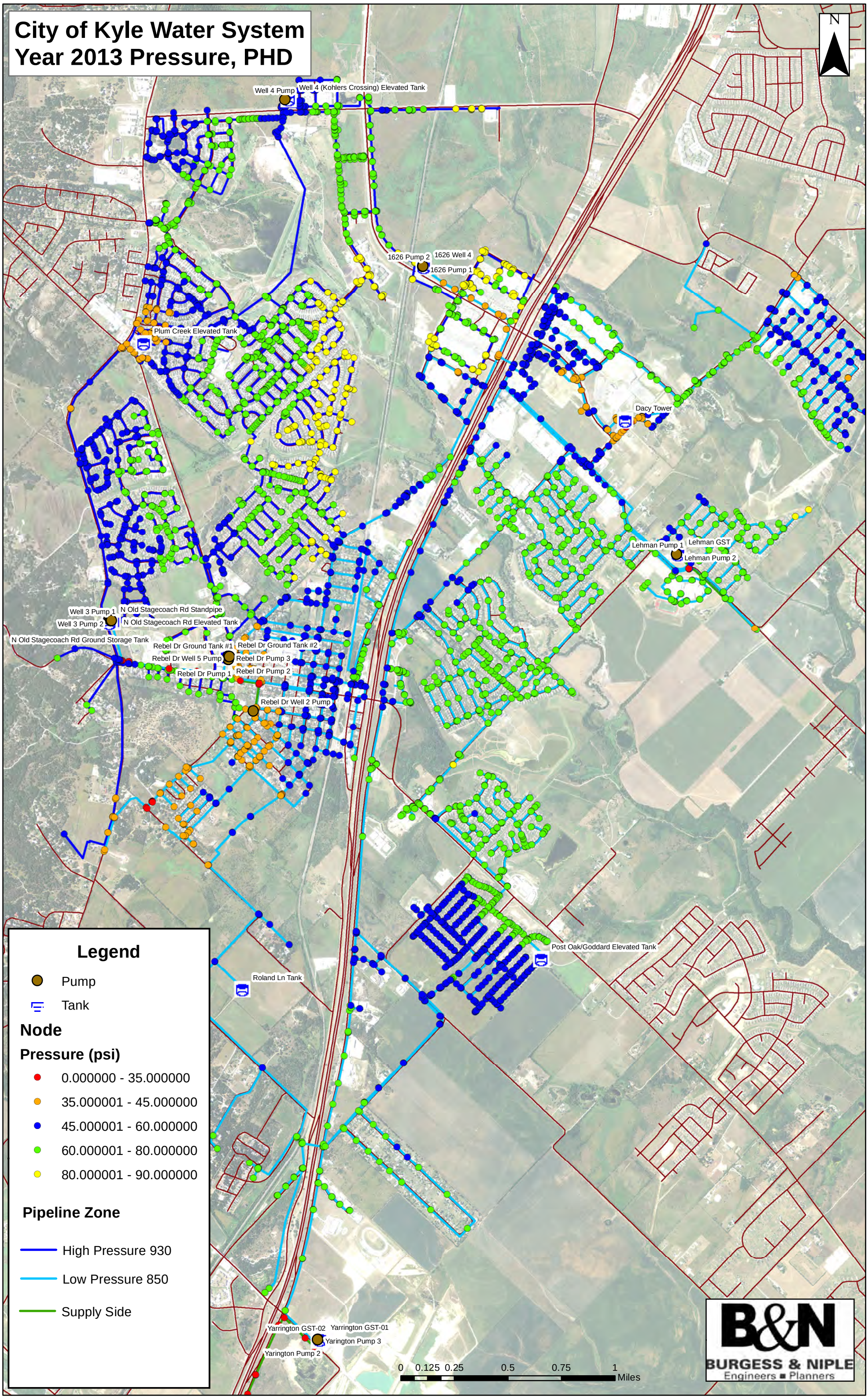

Well 4 EST
HGL (ft)
928
927
926
925
924
923
922
921
920
919
0
5
10
15
20
25
30
Time (hr)
Field 10/29/13
Model


Well 4 Pump
Flow (gpm)
700
600
500
400
300
200
100
0
0
5
10
15
20
25
30
Time (hr)
Field 10/29/13
Model

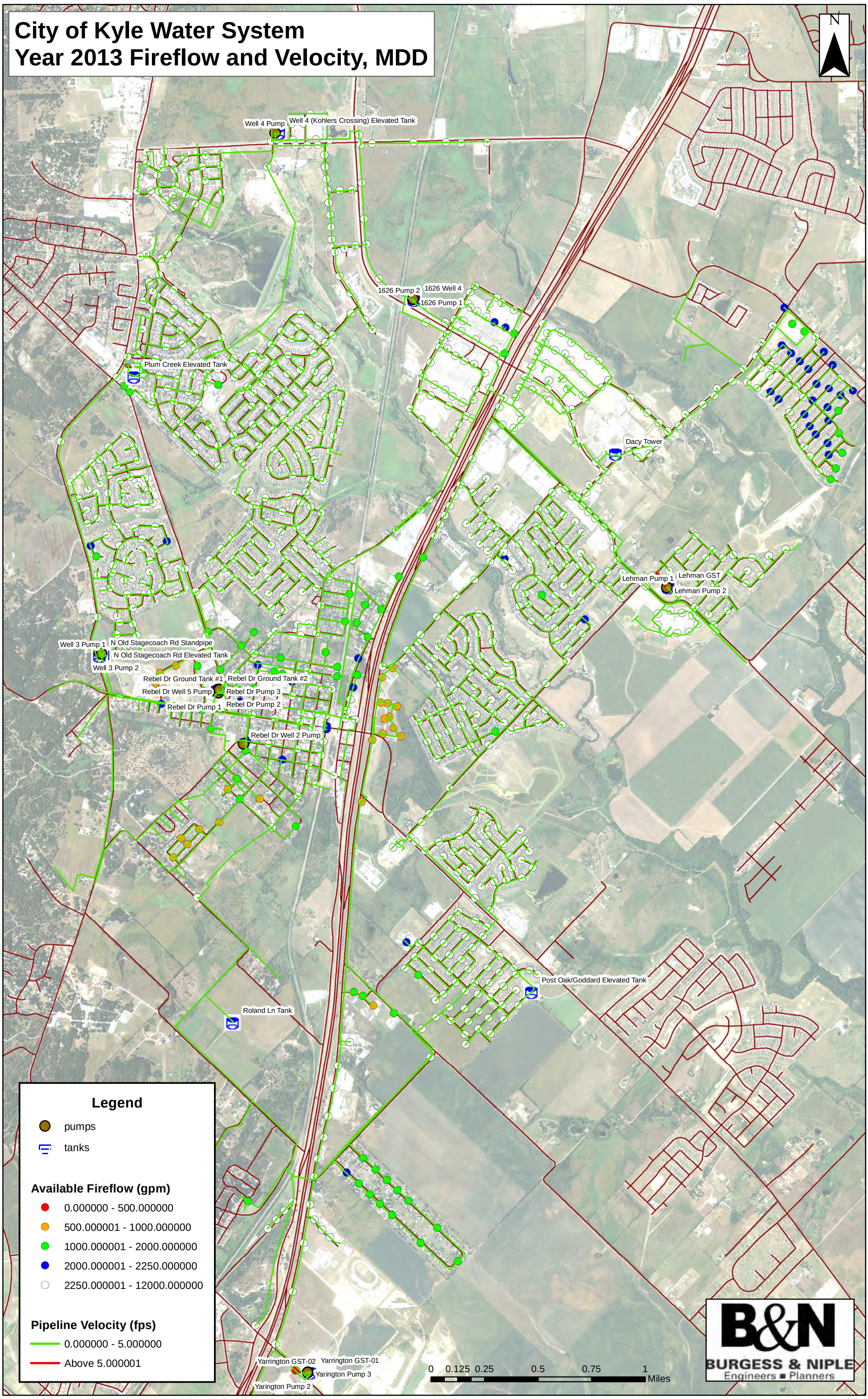

Yarrington Pump Station
Flow (gpm)
1000
800
600
400
200
0
0
5
10
15
20
25
30
Time (hr)
Field 10/29/13
Model

Appendix E

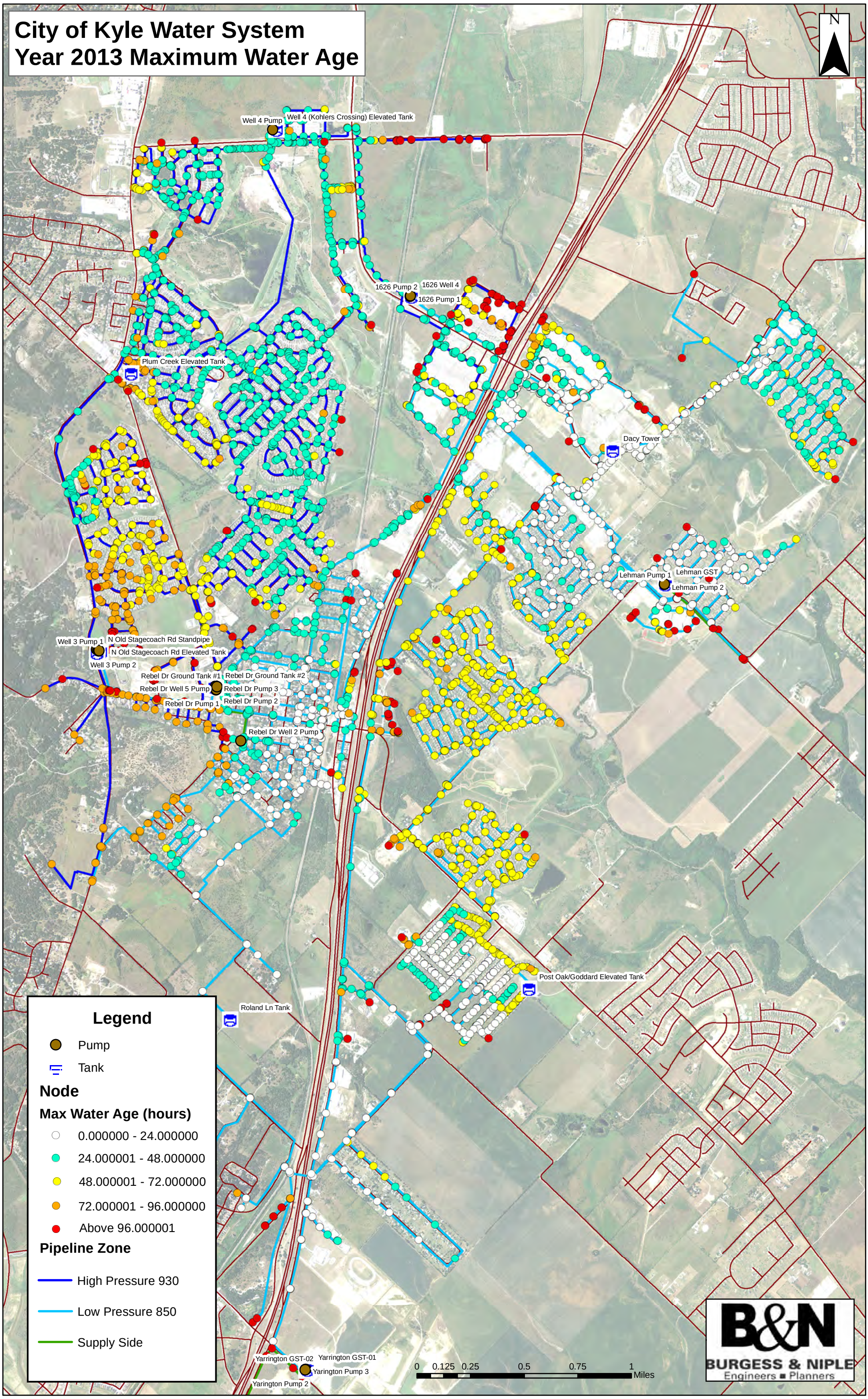
City of Kyle Water System
Year 2013 Pressure, PHD



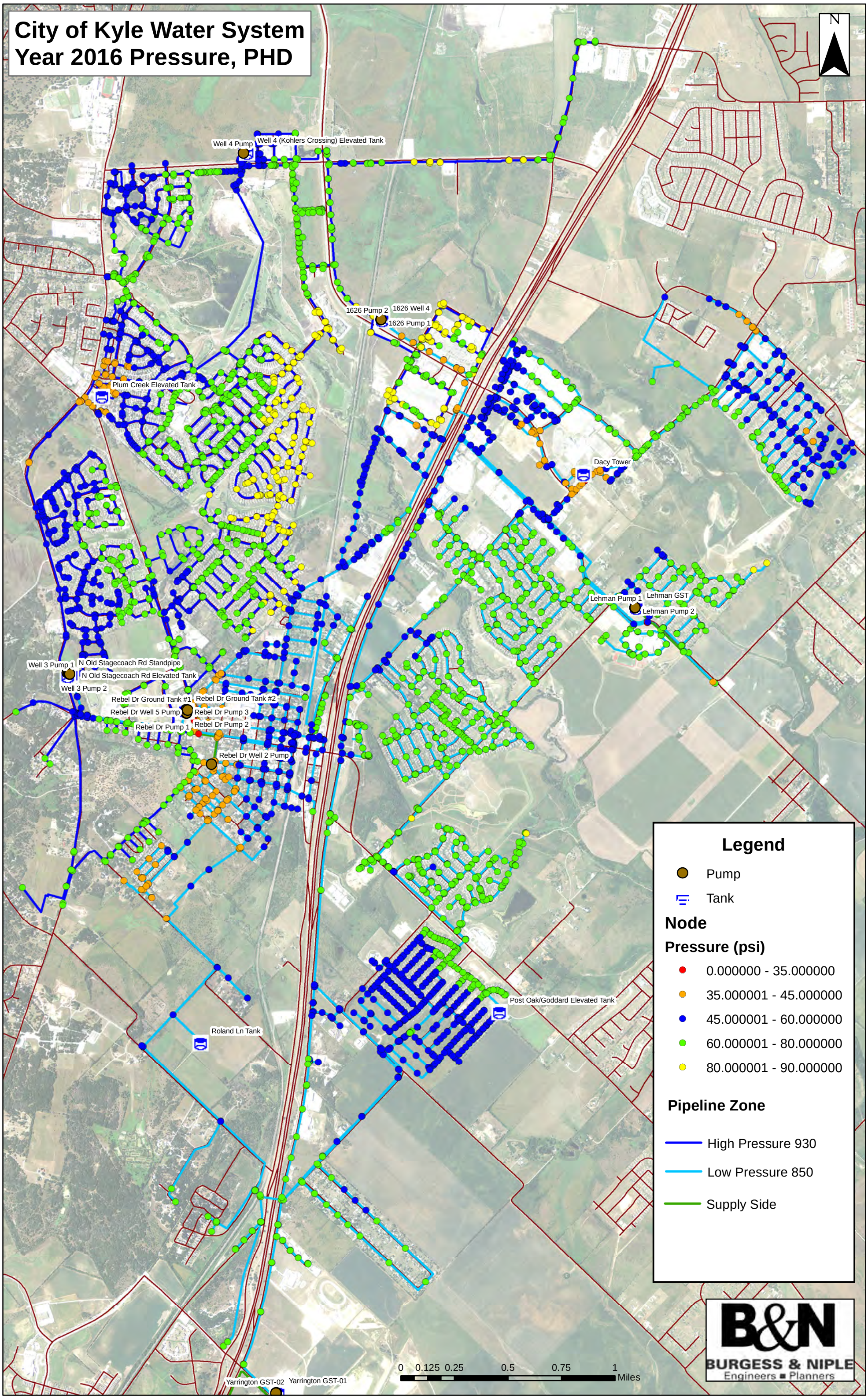
City of Kyle Water System
Year 2013 Fireflow and Velocity, MDD



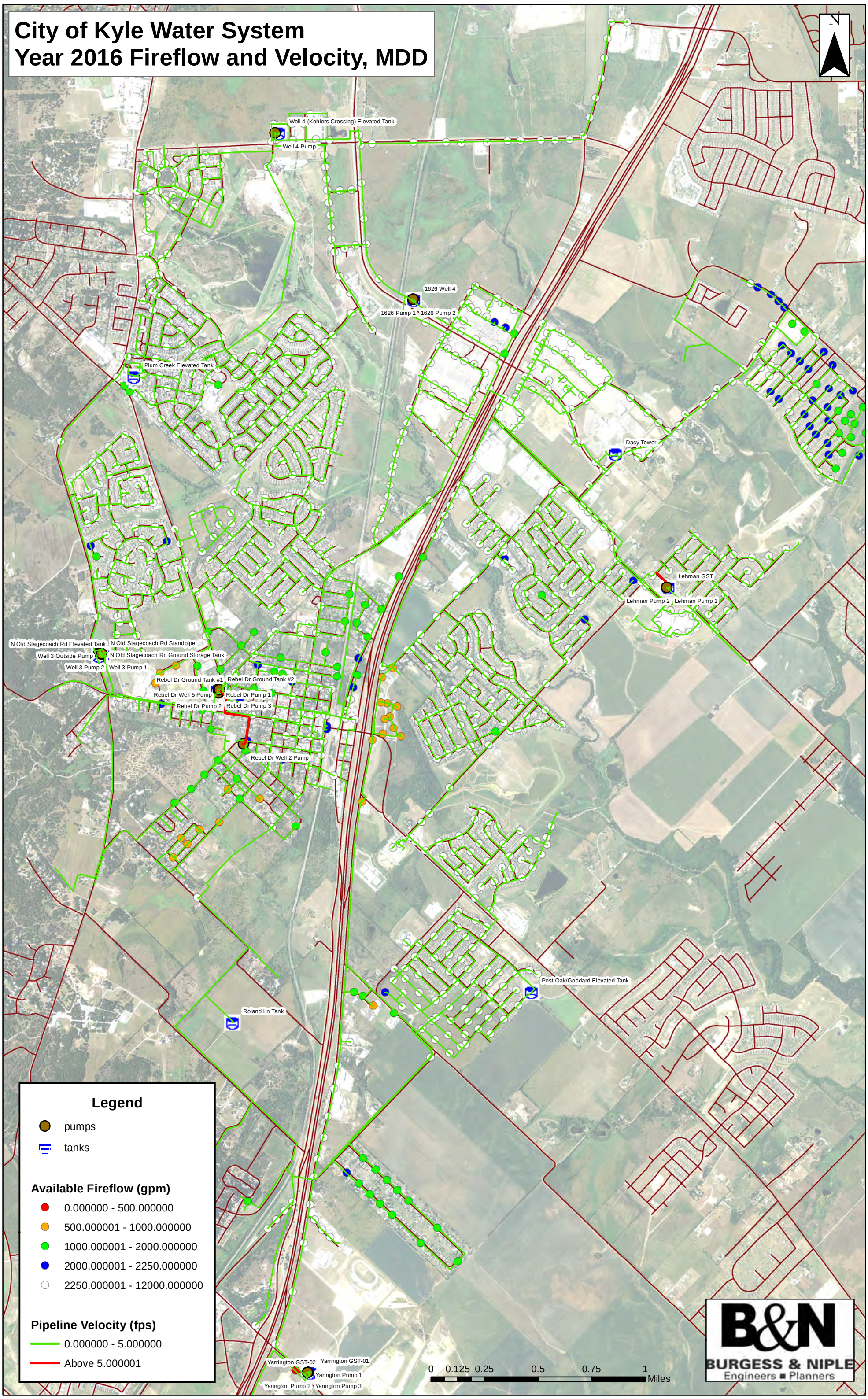
City of Kyle Water System
Year 2013 Maximum Water Age



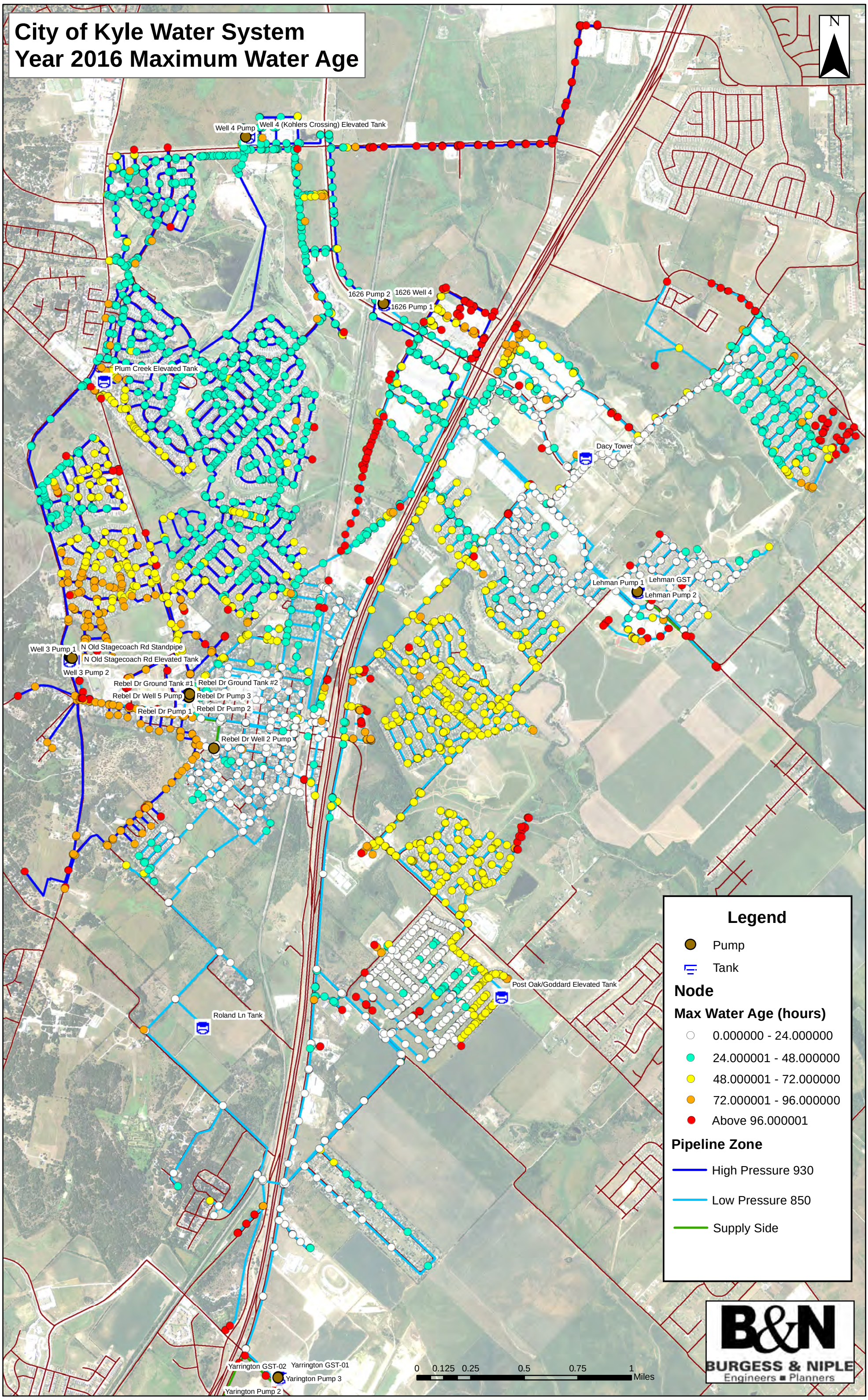
City of Kyle Water System
Year 2016 Pressure, PHD



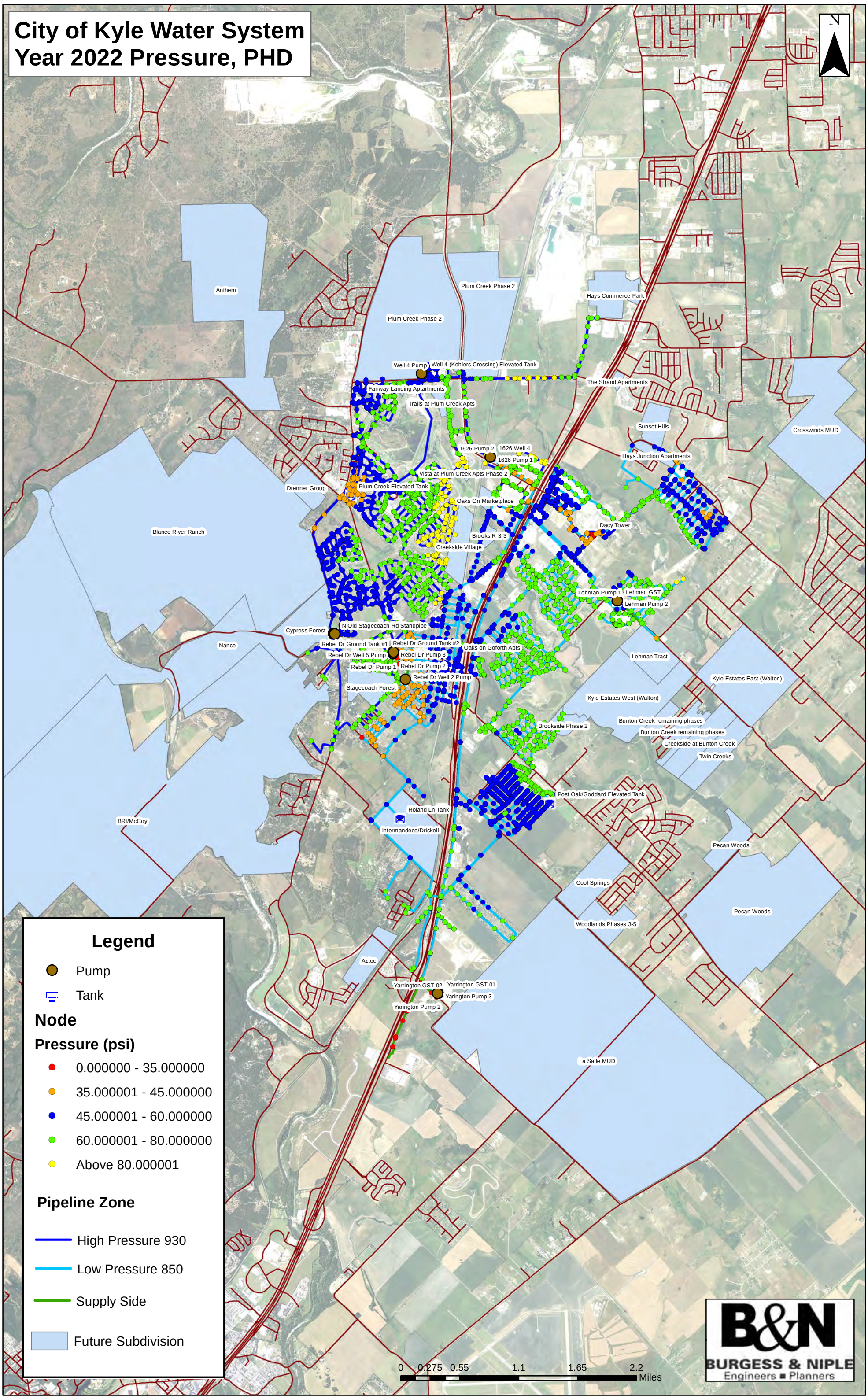
City of Kyle Water System
Year 2016 Fireflow and Velocity, MDD



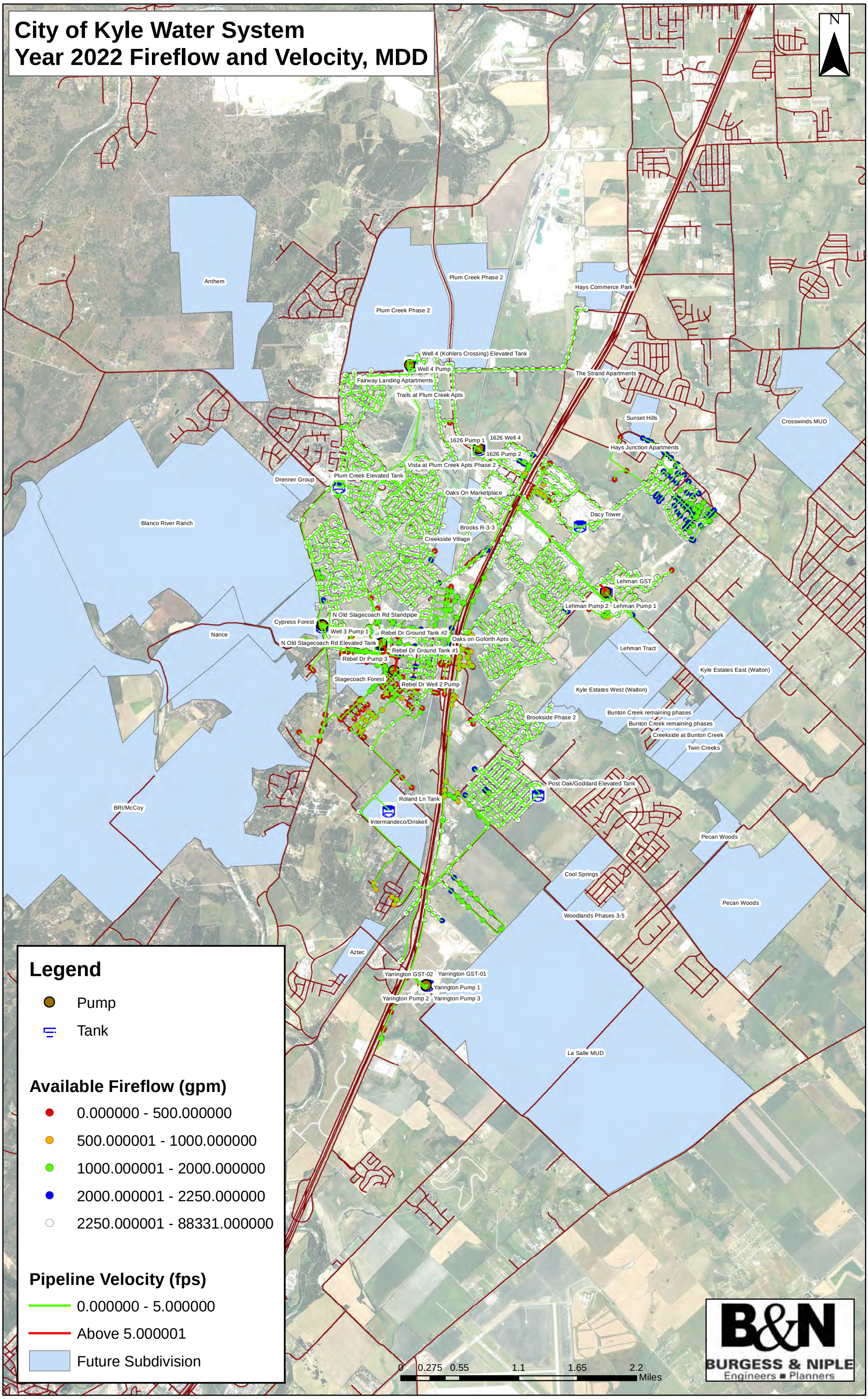
City of Kyle Water System
Year 2016 Maximum Water Age



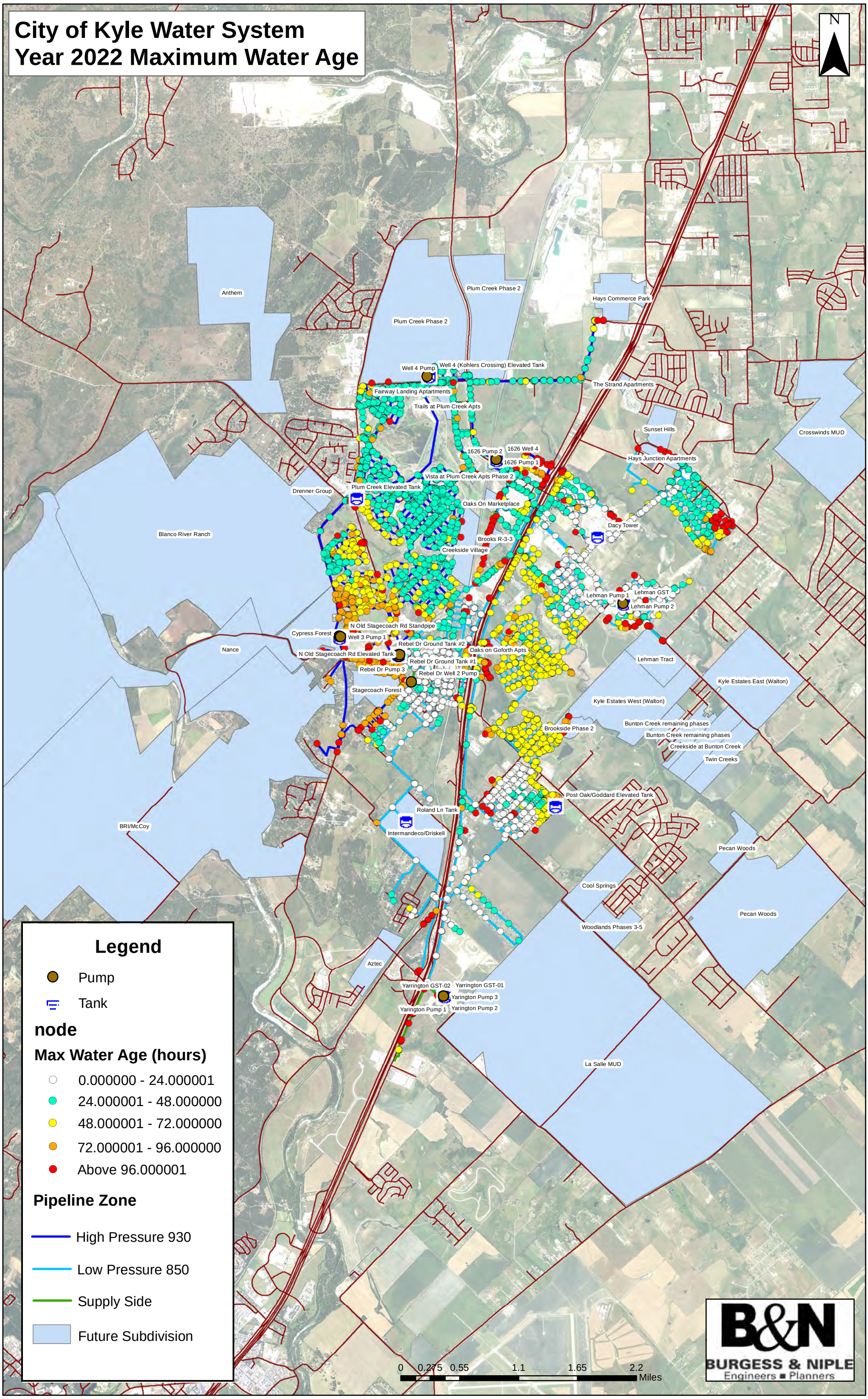
City of Kyle Water System
Year 2022 Pressure, PHD



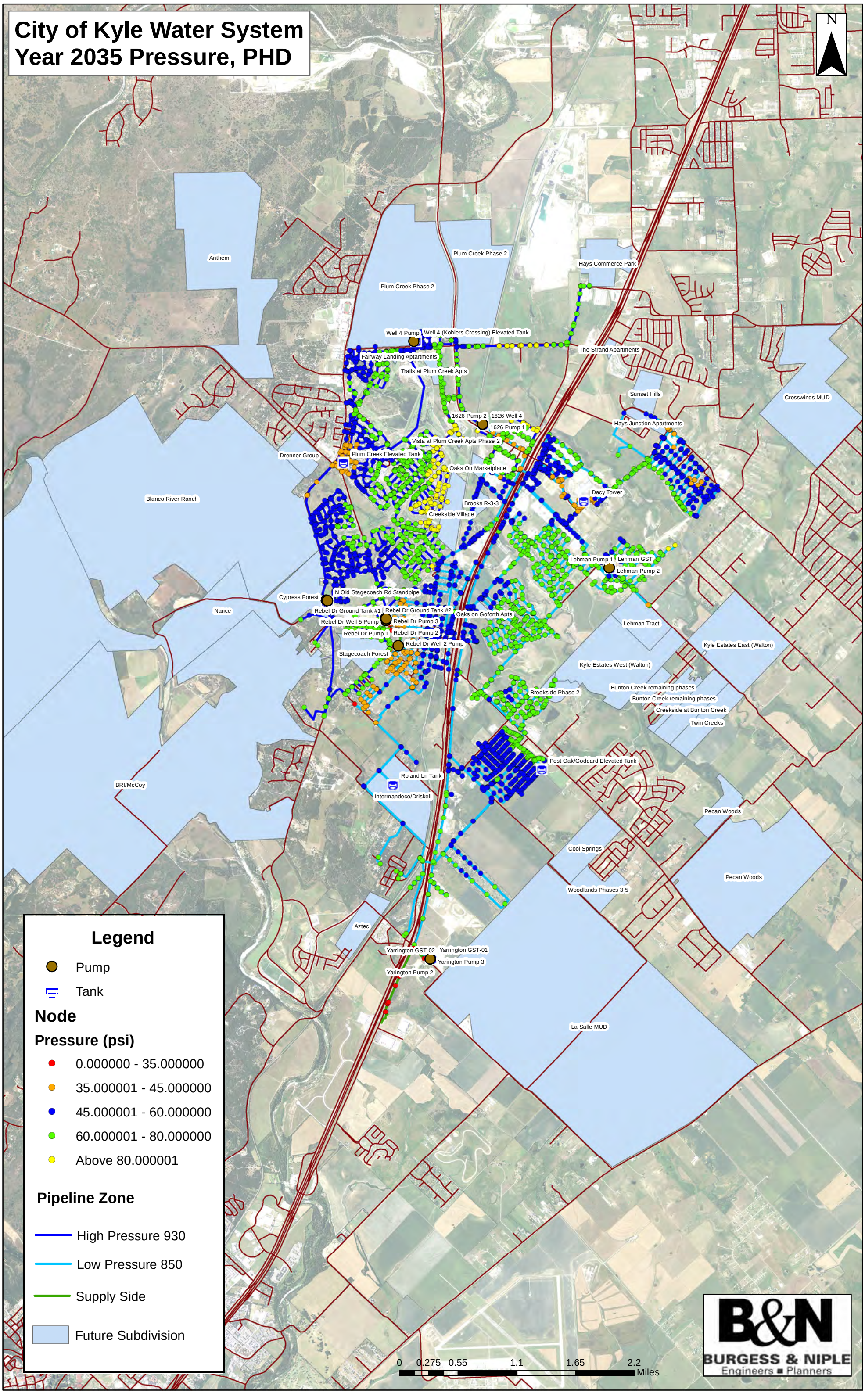
City of Kyle Water System
Year 2022 Fireflow and Velocity, MDD



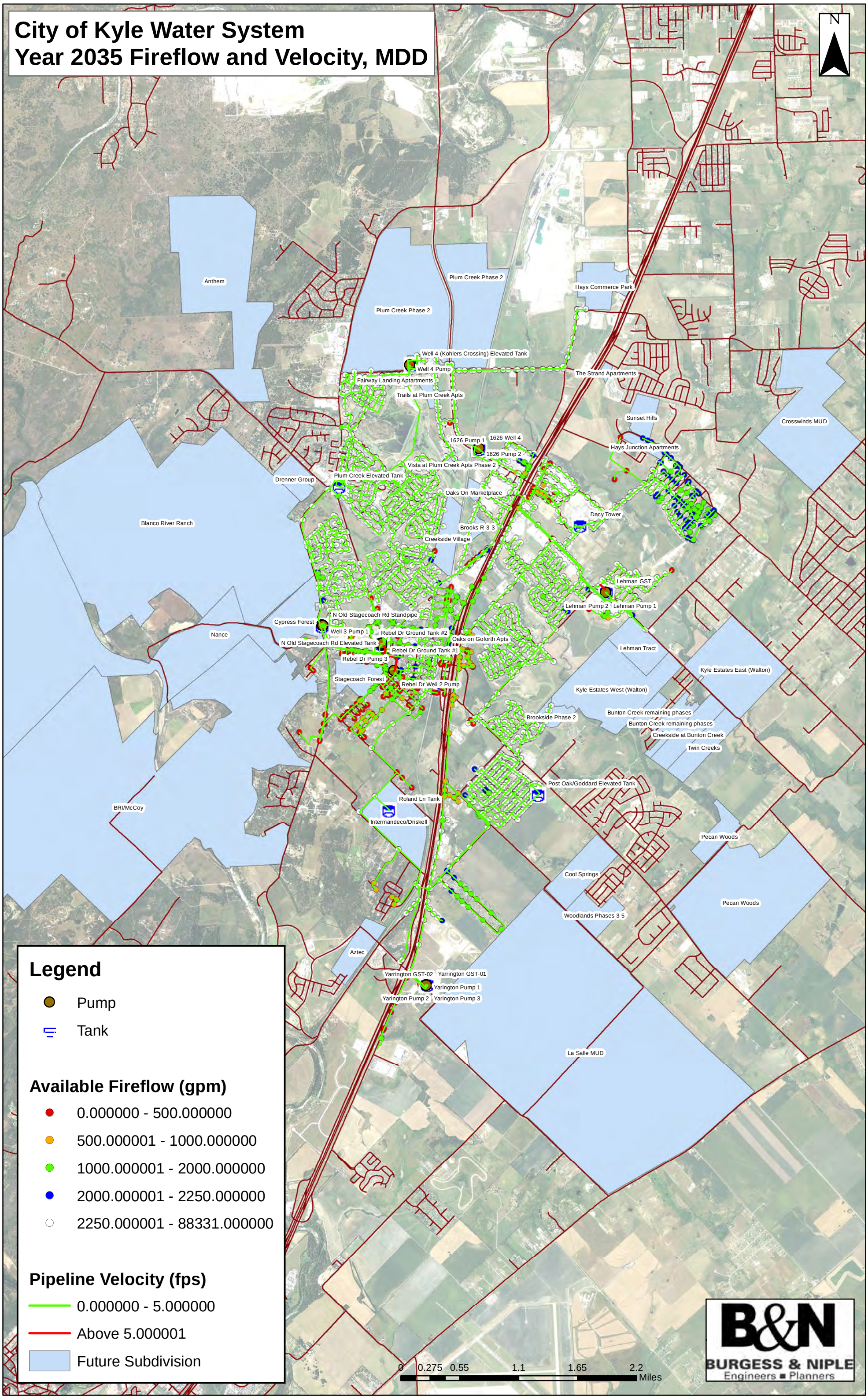
City of Kyle Water System
Year 2022 Maximum Water Age



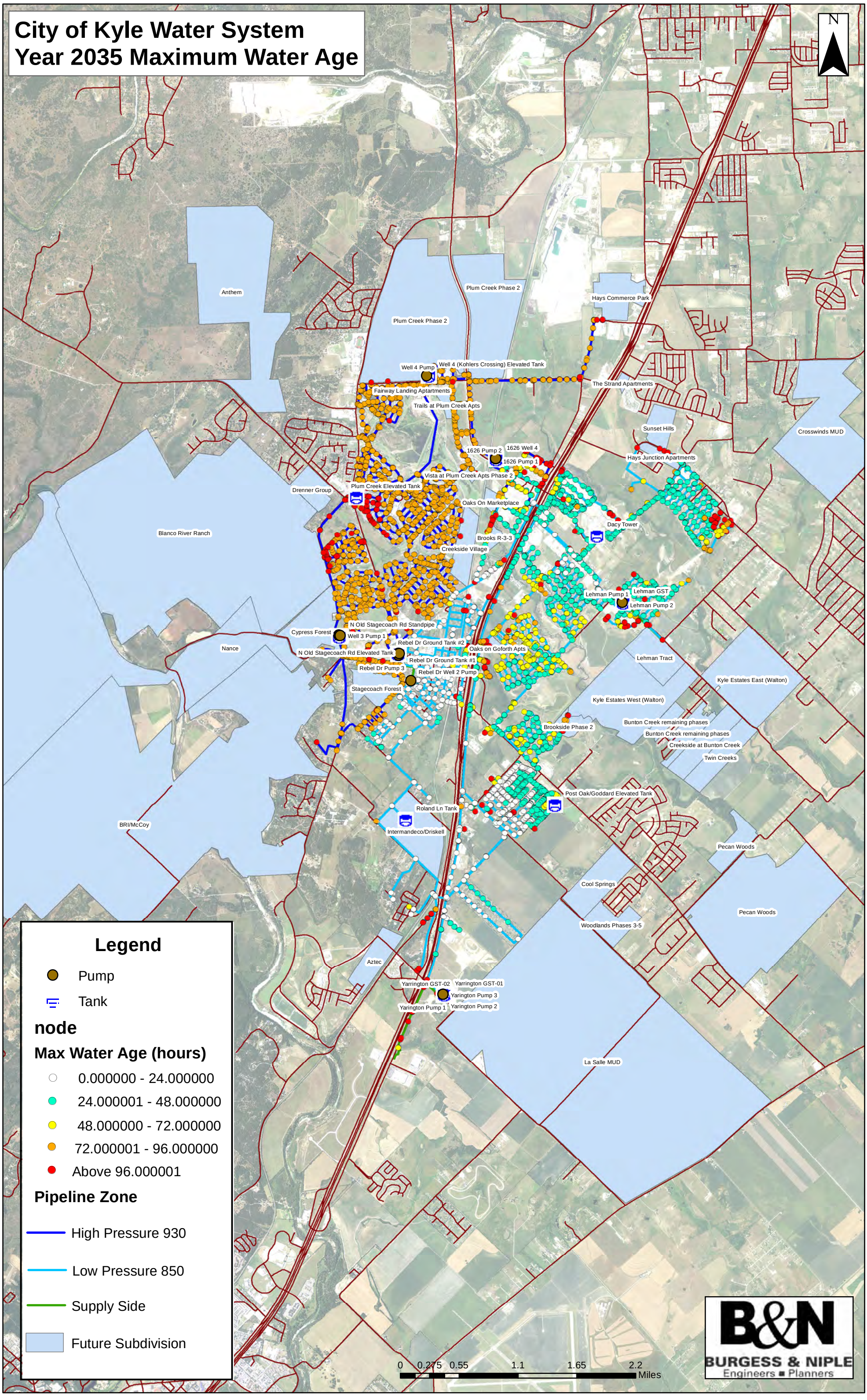
City of Kyle Water System
Year 2035 Pressure, PHD



City of Kyle Water System
Year 2035 Fireflow and Velocity, MDD



City of Kyle Water System
Year 2035 Maximum Water Age



Appendix F

Appendix F - Table F.1 City of Kyle Water Distribution System CIP Cost Summary	
Improvement Project	
Pipeline Improvement Projects	Estimated Cost
Anthem	$1,389,100
Aztec	$358,700
Blanco River Ranch	$1,321,500
Crosswinds MUD	$1,367,400
La Salle MUD	$269,000
Pecan Woods	$2,286,500
West Blanco Street	$388,300
Well 2 transmission main	$421,900
Lehman transmission main	$269,000
Opal Lane	$449,600
South Old Stagecoach Road	$1,266,900
Third Pressure Zone Supply Pipeline	$1,672,000
Total	**$11,459,900**
Storage Improvements	
Third Pressure Zone Storage	$7,132,500
Low Pressure Zone Storage	$3,887,400
Total	**$11,019,900**
Supply Improvements	
Supply to Existing System	$333,300
Booster Pump from High Pressure Zone to Third Pressure Zone	$1,131,200
Total	**$1,464,500**
Pump Replacements	
Lehman	$39,700
Yarrington	$59,600
Well 3	$19,900
Well 5	$19,900
Rebel Road Service	$59,600
1626	$39,700
Total	**$238,400**
Small Diameter Pipeline	
Replace pipelines smaller than 6-inches	$6,263,600
Total	**$6,263,600**

Appendix F - Table F.2 City of Kyle Water Distribution System Pipeline CIP Cost Estimate

Improvement Project	Projected Pipeline size (in)	Estimated Pipeline length (lf)	Unit Price ($/lf)	Total Pipeline Cost	Land Area (acre)	Grass (sy)	Seeding and Mulching Cost	Pipeline in Asphalt (lf)	Asphalt (sf)	Asphalt Cost	Estimated Number of Hydrants (every 400 feet)	Total Hydrant Cost	Estimated Number of Gate Valves (every 250 feet)	Total Gate Valve Cost	Estimated Preliminary Construction Cost	Estimated Enigineering Cost	Contingency Cost	Total Estimated Cost
Anthem	16	5,400	$120	$648,000	674	0	$0	5,400	16,200	$291,600	14	$67,500	22	$43,200	$1,050,300	$157,545	$181,177	$1,389,100
Aztec	12	1,600	$95	$152,000	672	0	$0	1,600	4,800	$86,400	4	$20,000	6	$12,800	$271,200	$40,680	$46,782	$358,700
Blanco River Ranch	12	3,600	$95	$342,000	2,167	0	$0	3,600	10,800	$194,400	9	$45,000	14	$28,800	$999,200	$149,880	$172,362	$1,321,500
	16	2,000	$120	$240,000		0	$0	2,000	6,000	$108,000	5	$25,000	8	$16,000				
Crosswinds MUD	12	6,100	$95	$579,500	444	0	$0	6,100	18,300	$329,400	15	$76,250	24	$48,800	$1,033,950	$155,093	$178,356	$1,367,400
La Salle MUD	12	1,200	$95	$114,000	2,740	0	$0	1,200	3,600	$64,800	3	$15,000	5	$9,600	$203,400	$30,510	$35,087	$269,000
Pecan Woods	12	10,200	$95	$969,000	768	0	$0	10,200	30,600	$550,800	26	$127,500	41	$81,600	$1,728,900	$259,335	$298,235	$2,286,500
West Blanco Street	8	1,900	$80	$152,000		0	$0	1,900	5,700	$102,600	5	$23,750	8	$15,200	$293,550	$44,033	$50,637	$388,300
Well 2 transmission main	10	2,000	$85	$170,000		0	$0	2,000	6,000	$108,000	5	$25,000	8	$16,000	$319,000	$47,850	$55,028	$421,900
Lehman transmission main	12	1,200	$95	$114,000		0	$0	1,200	3,600	$64,800	3	$15,000	5	$9,600	$203,400	$30,510	$35,087	$269,000
Opal Lane	8	2,200	$80	$176,000		0	$0	2,200	6,600	$118,800	6	$27,500	9	$17,600	$339,900	$50,985	$58,633	$449,600
South Old Stagecoach Road	8	6,200	$80	$496,000		0	$0	6,200	18,600	$334,800	16	$77,500	25	$49,600	$957,900	$143,685	$165,238	$1,266,900
Small Diameter Pipeline	6	31,680	$75	$2,376,000		0	$0	31,680	95,040	$1,710,720	79	$396,000	127	$253,440	$4,736,160	$710,424	$816,988	$6,263,600
Third Pressure Zone Supply Pipeline	16	6,500	$120	$780,000		0	$0	6,500	19,500	$351,000	16	$81,250	26	$52,000	$1,264,250	$189,638	$218,083	$1,672,000
																	Total	**$16,051,500**

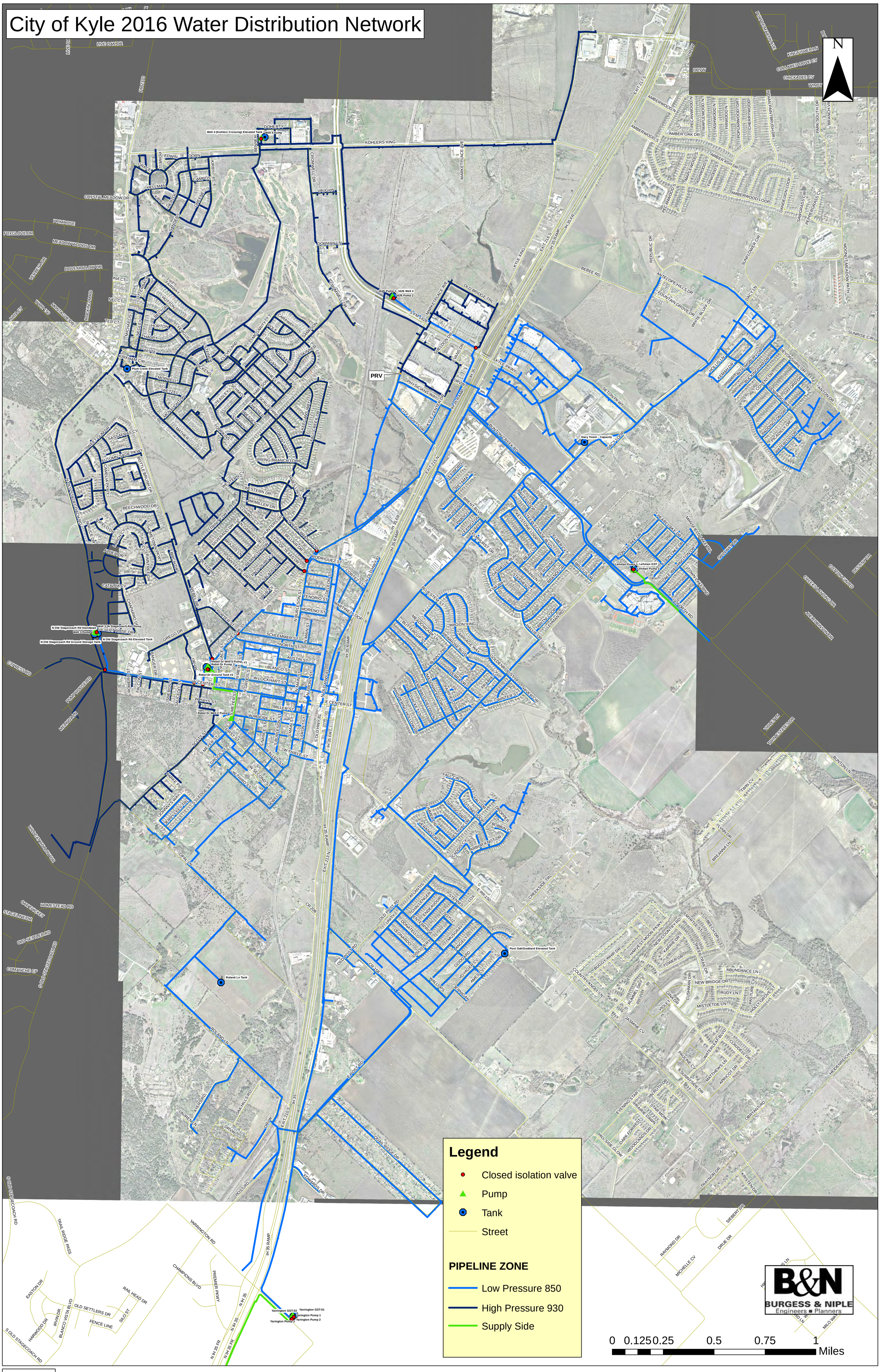
Appendix F - Table F.3 City of Kyle Water Distribution System Pump Replacement CIP Cost Estimate						
Improvement Project	Each	Unit Price ($)	Estimated Preliminary Construction Cost	Estimated Enigineering Cost	Contingency	Total Estimated Cost
Lehman	2.00	$15,000	$30,000	$4,500	$5,175	$39,700
Yarrington	3.00	$15,000	$45,000	$6,750	$7,763	$59,600
Well 3	1.00	$15,000	$15,000	$2,250	$2,588	$19,900
Well 5	1.00	$15,000	$15,000	$2,250	$2,588	$19,900
Rebel Road Service	3.00	$15,000	$45,000	$6,750	$7,763	$59,600
1626	2.00	$15,000	$30,000	$4,500	$5,175	$39,700
					Total	**$238,400**

Appendix F - Table F.4 City of Kyle Water Distribution System Storage CIP Cost Estimate						
Improvement Project	Storage (MG)	Unit Price ($/MG)	Estimated Preliminary Construction Cost	Estimated Enigineering Cost	Contingency	Total Estimated Cost
Third Pressure Zone Storage	2.11	$5,393,160	$5,393,160	$808,974	$930,320	$7,132,500
Low Pressure Zone Storage	1.15	$2,939,400	$2,939,400	$440,910	$507,047	$3,887,400
					Total	**$11,019,900**

Appendix F - Table F.5 City of Kyle Water Distribution System Pump Supply CIP Cost Estimate							
Improvement Project	Capacity (gpm)	Capacity (MGD)	Unit Price ($/MGD)	Estimated Preliminary Construction Cost	Estimated Enigineering Cost	Contingency	Total Estimated Cost
Supply to Existing System	500	1	$350,000	$252,000	$37,800	$43,470	$333,300
Booster Pump from High Pressure Zone to Third Pressure Zone	1,697	2	$350,000	$855,288	$128,293	$147,537	$1,131,200
						Total	**$1,464,500**

Appendix G

City of Kyle 2016 Water Distribution Network

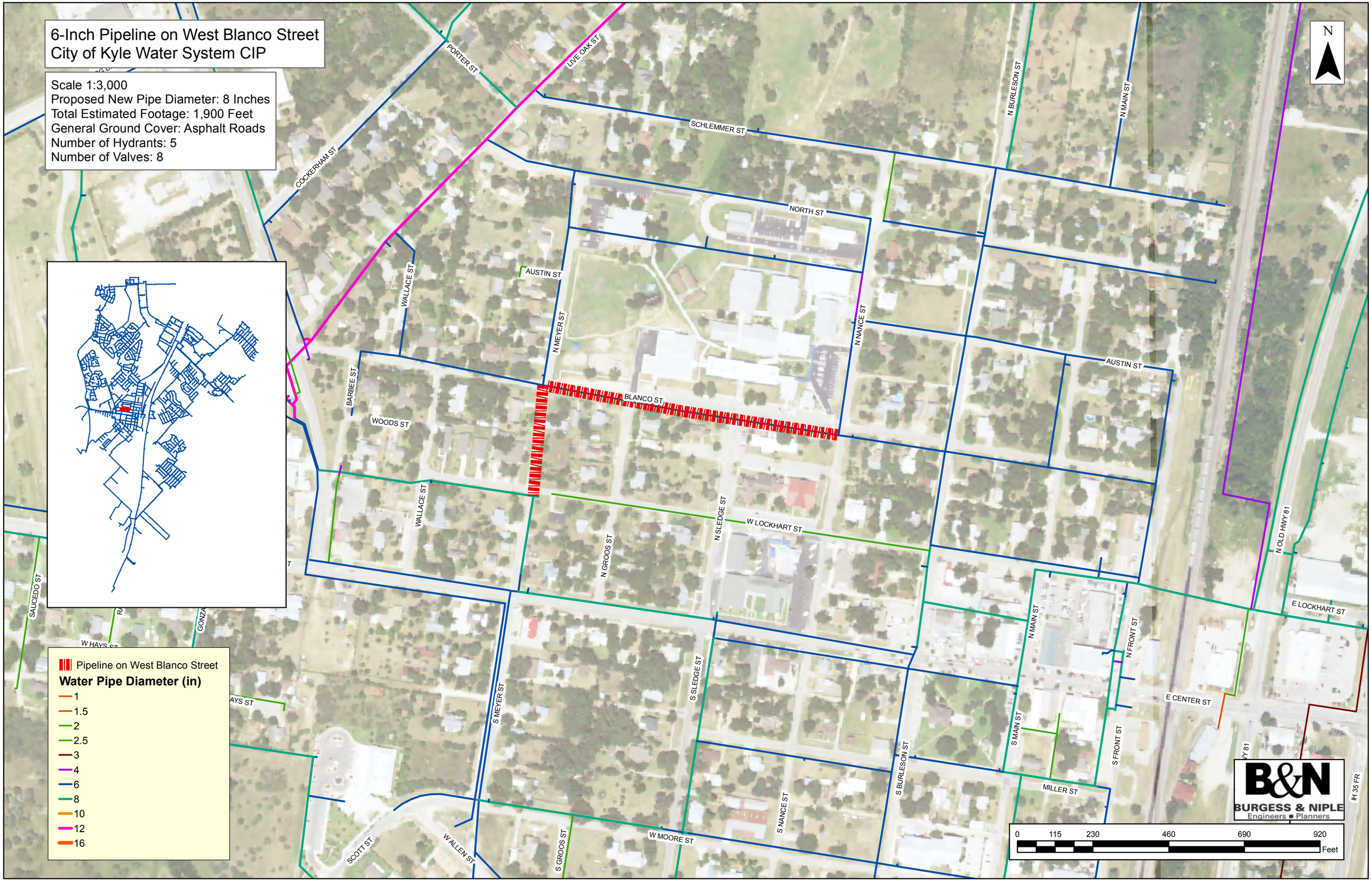


July 2016

Appendix H

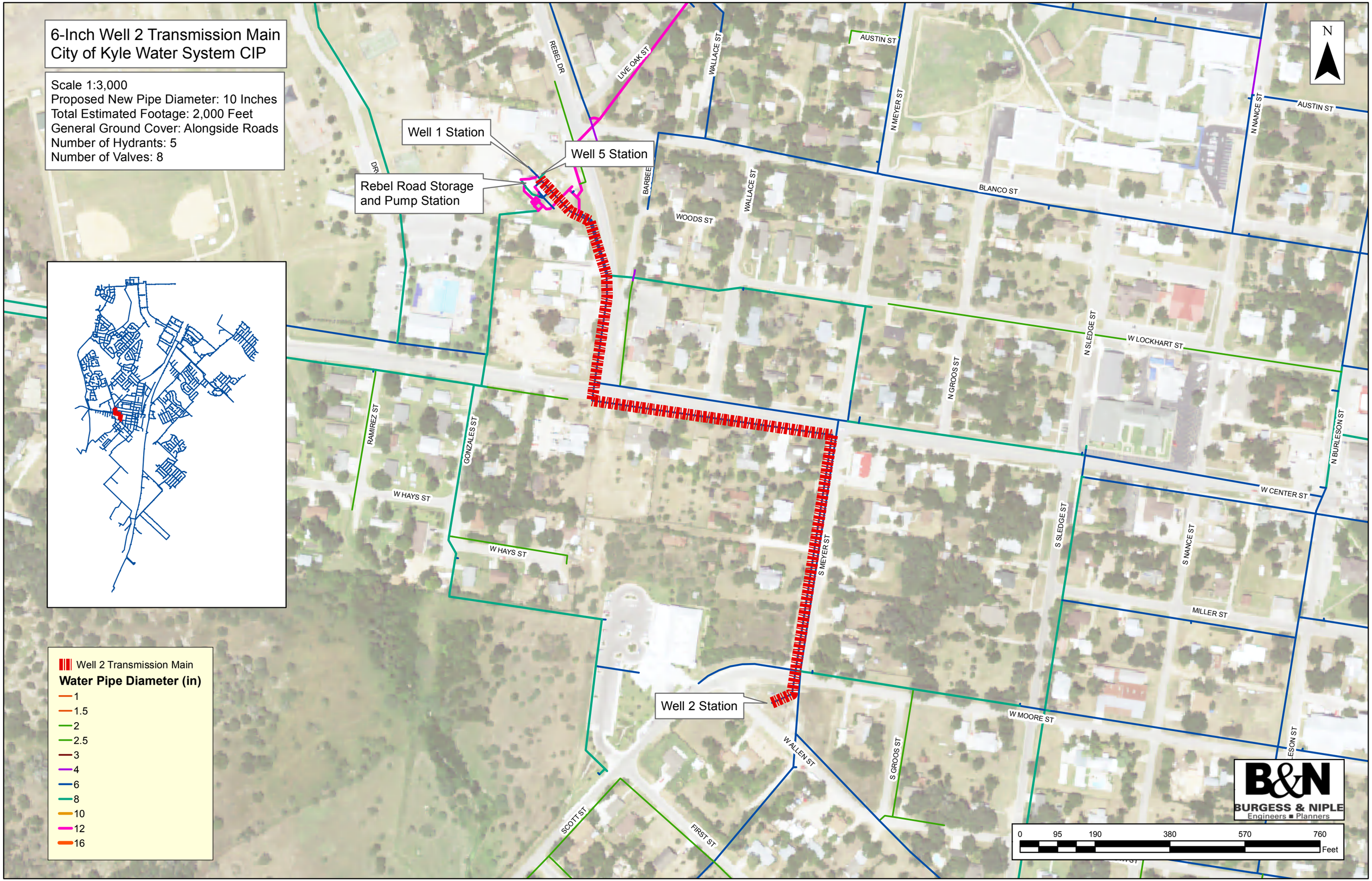
6-Inch Pipeline on West Blanco Street
City of Kyle Water System CIP

Scale 1:3,000
Proposed New Pipe Diameter: 8 Inches
Total Estimated Footage: 1,900 Feet
General Ground Cover: Asphalt Roads
Number of Hydrants: 5
Number of Valves: 8



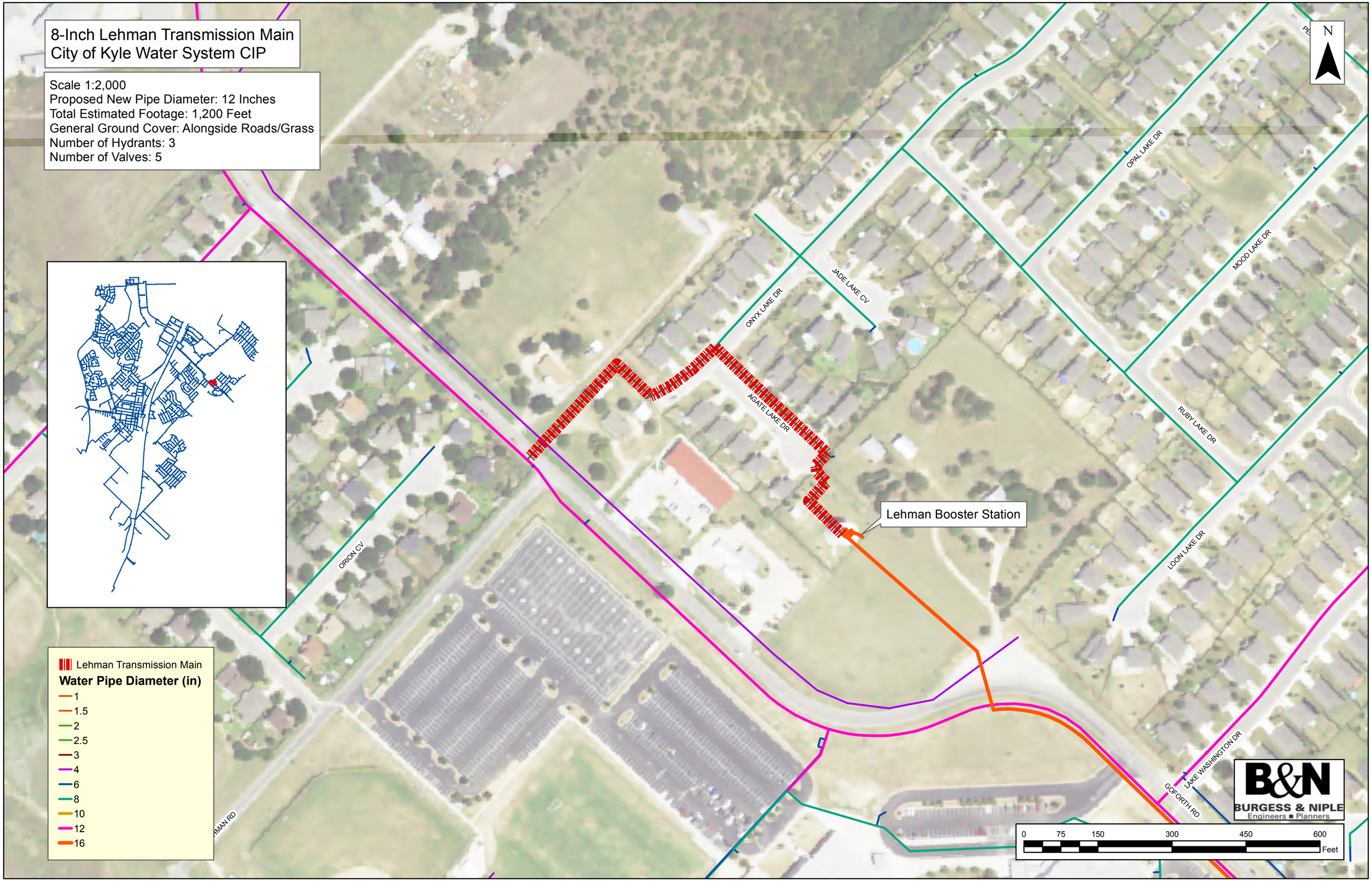
6-Inch Well 2 Transmission Main
City of Kyle Water System CIP

Scale 1:3,000
Proposed New Pipe Diameter: 10 Inches
Total Estimated Footage: 2,000 Feet
General Ground Cover: Alongside Roads
Number of Hydrants: 5
Number of Valves: 8



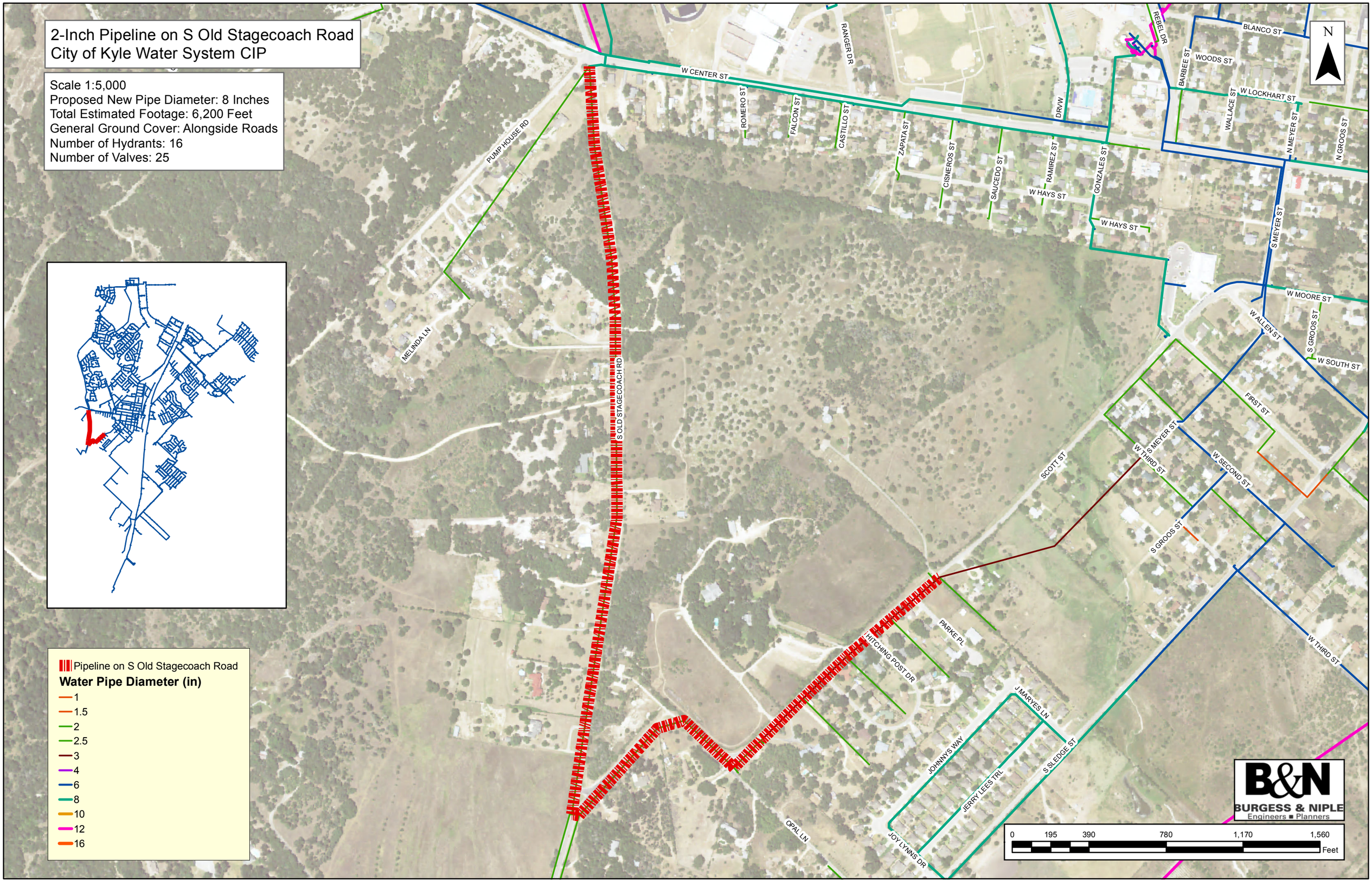
8-Inch Lehman Transmission Main
City of Kyle Water System CIP

Scale 1:2,000
Proposed New Pipe Diameter: 12 Inches
Total Estimated Footage: 1,200 Feet
General Ground Cover: Alongside Roads/Grass
Number of Hydrants: 3
Number of Valves: 5



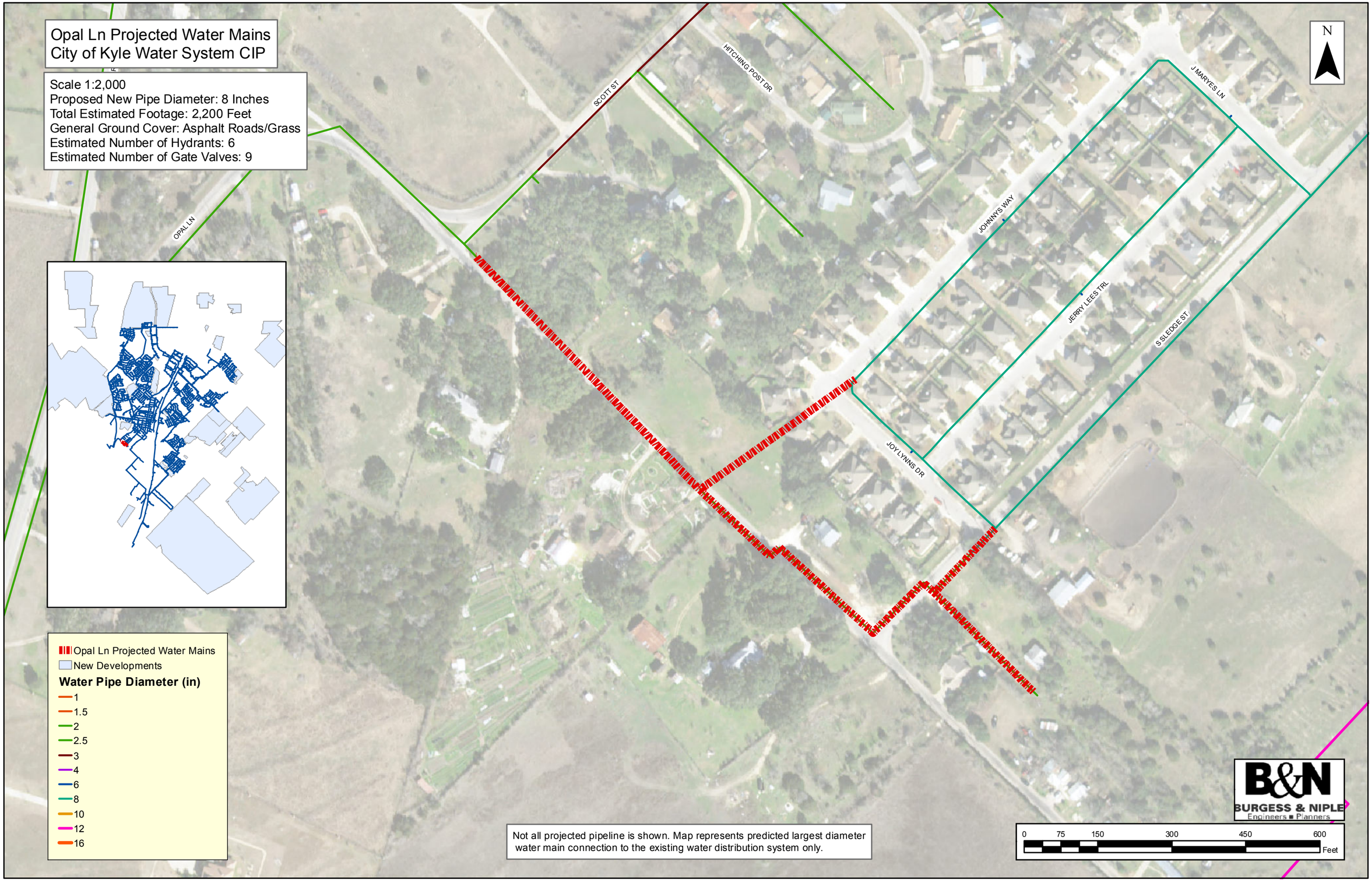
2-Inch Pipeline on S Old Stagecoach Road
City of Kyle Water System CIP

Scale 1:5,000
Proposed New Pipe Diameter: 8 Inches
Total Estimated Footage: 6,200 Feet
General Ground Cover: Alongside Roads
Number of Hydrants: 16
Number of Valves: 25



Opal Ln Projected Water Mains
City of Kyle Water System CIP

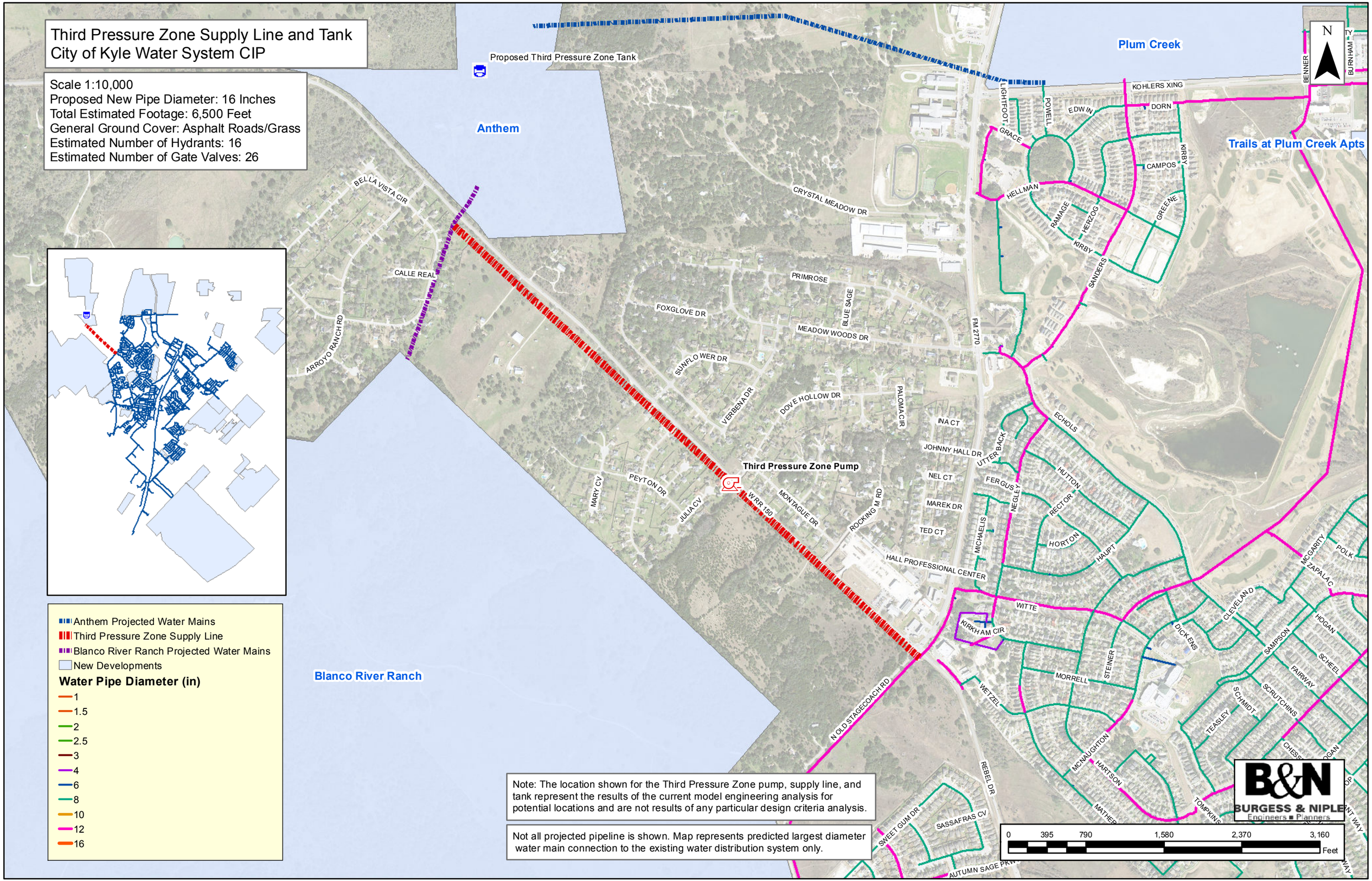
Scale 1:2,000
Proposed New Pipe Diameter: 8 Inches
Total Estimated Footage: 2,200 Feet
General Ground Cover: Asphalt Roads/Grass
Estimated Number of Hydrants: 6
Estimated Number of Gate Valves: 9



Not all projected pipeline is shown. Map represents predicted largest diameter water main connection to the existing water distribution system only.

Third Pressure Zone Supply Line and Tank
City of Kyle Water System CIP

Scale 1:10,000
Proposed New Pipe Diameter: 16 Inches
Total Estimated Footage: 6,500 Feet
General Ground Cover: Asphalt Roads/Grass
Estimated Number of Hydrants: 16
Estimated Number of Gate Valves: 26

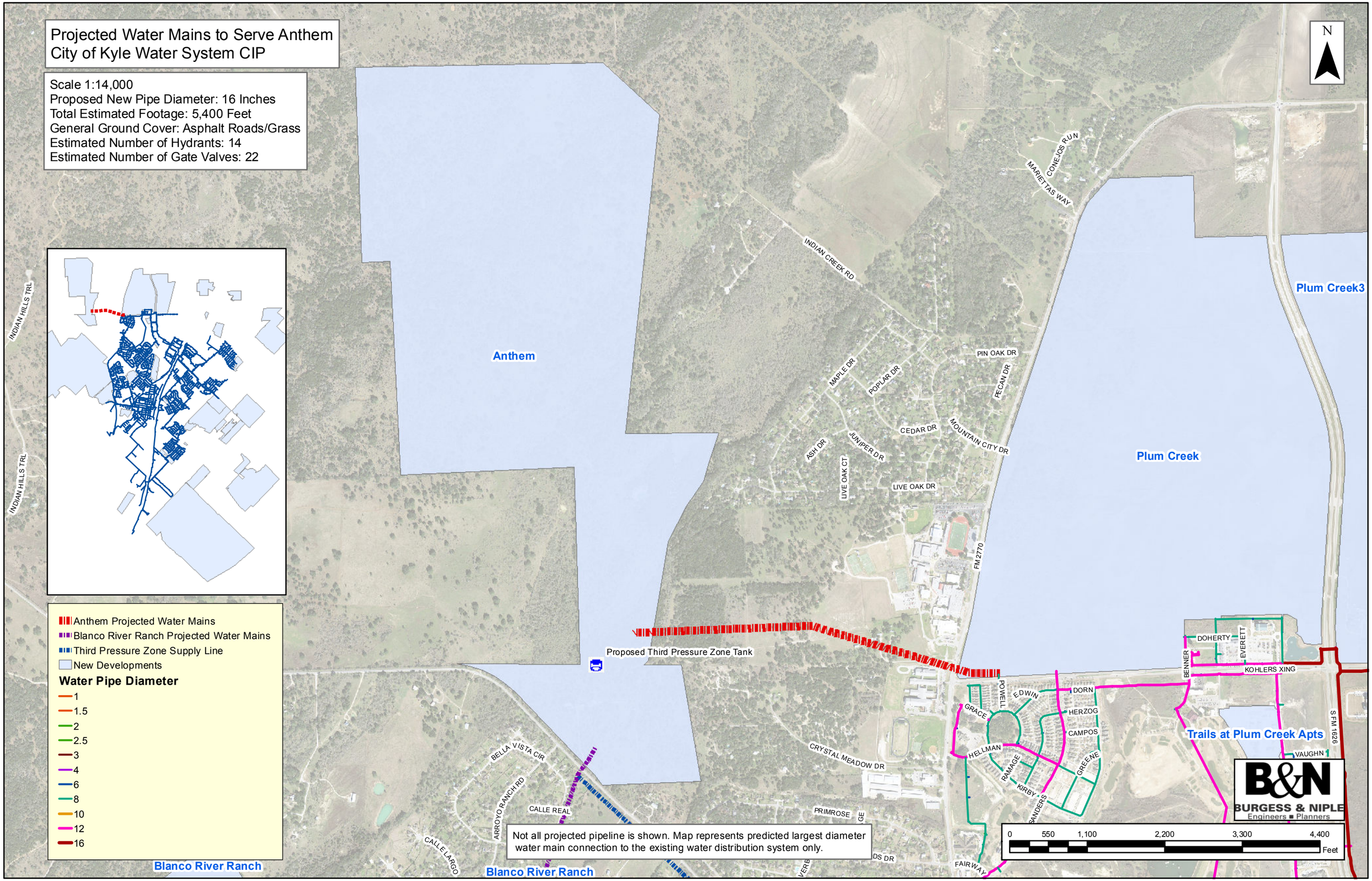


Note: The location shown for the Third Pressure Zone pump, supply line, and tank represent the results of the current model engineering analysis for potential locations and are not results of any particular design criteria analysis.

Not all projected pipeline is shown. Map represents predicted largest diameter water main connection to the existing water distribution system only.

Projected Water Mains to Serve Anthem
City of Kyle Water System CIP

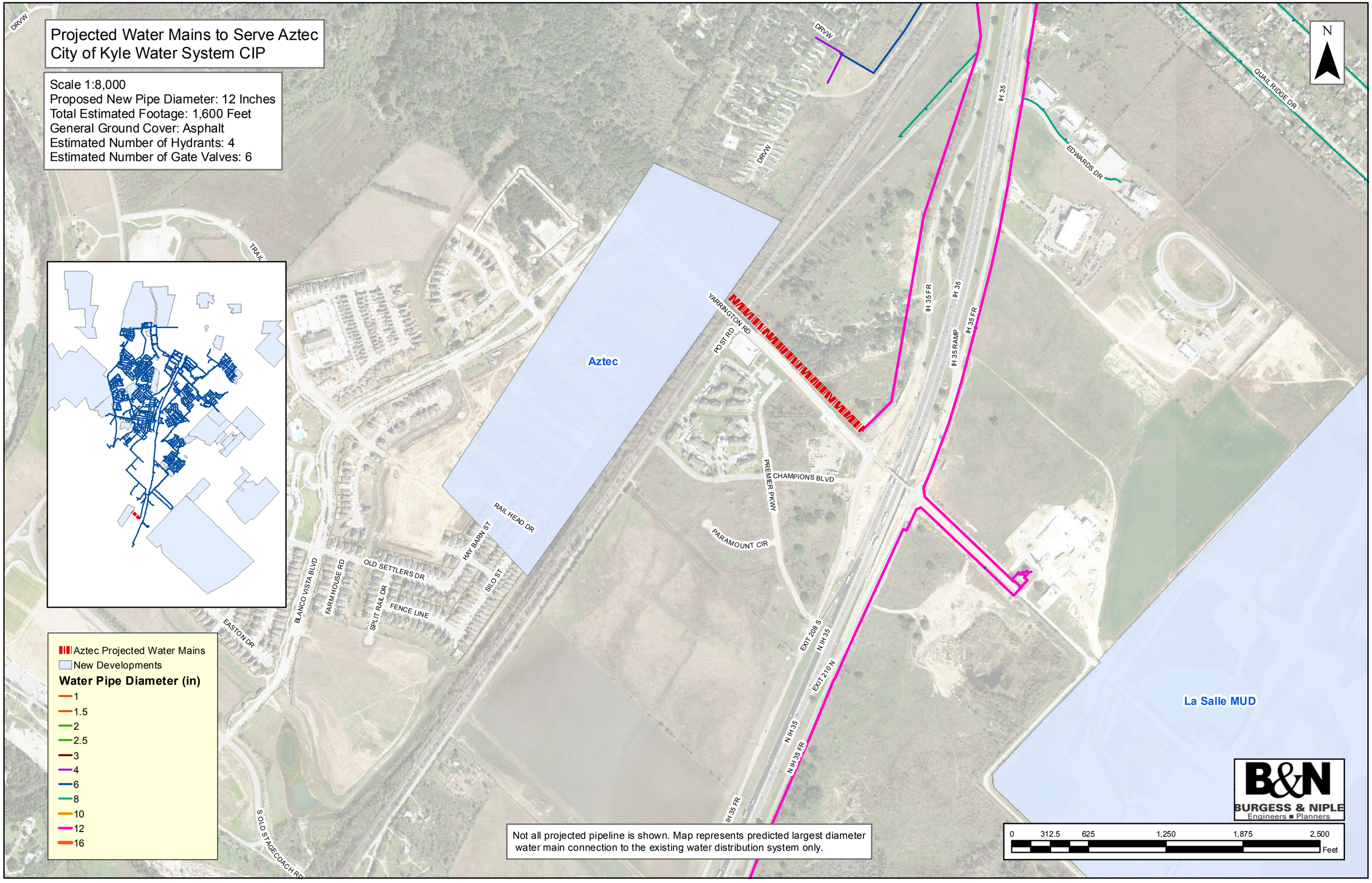
Scale 1:14,000
Proposed New Pipe Diameter: 16 Inches
Total Estimated Footage: 5,400 Feet
General Ground Cover: Asphalt Roads/Grass
Estimated Number of Hydrants: 14
Estimated Number of Gate Valves: 22



Not all projected pipeline is shown. Map represents predicted largest diameter water main connection to the existing water distribution system only.

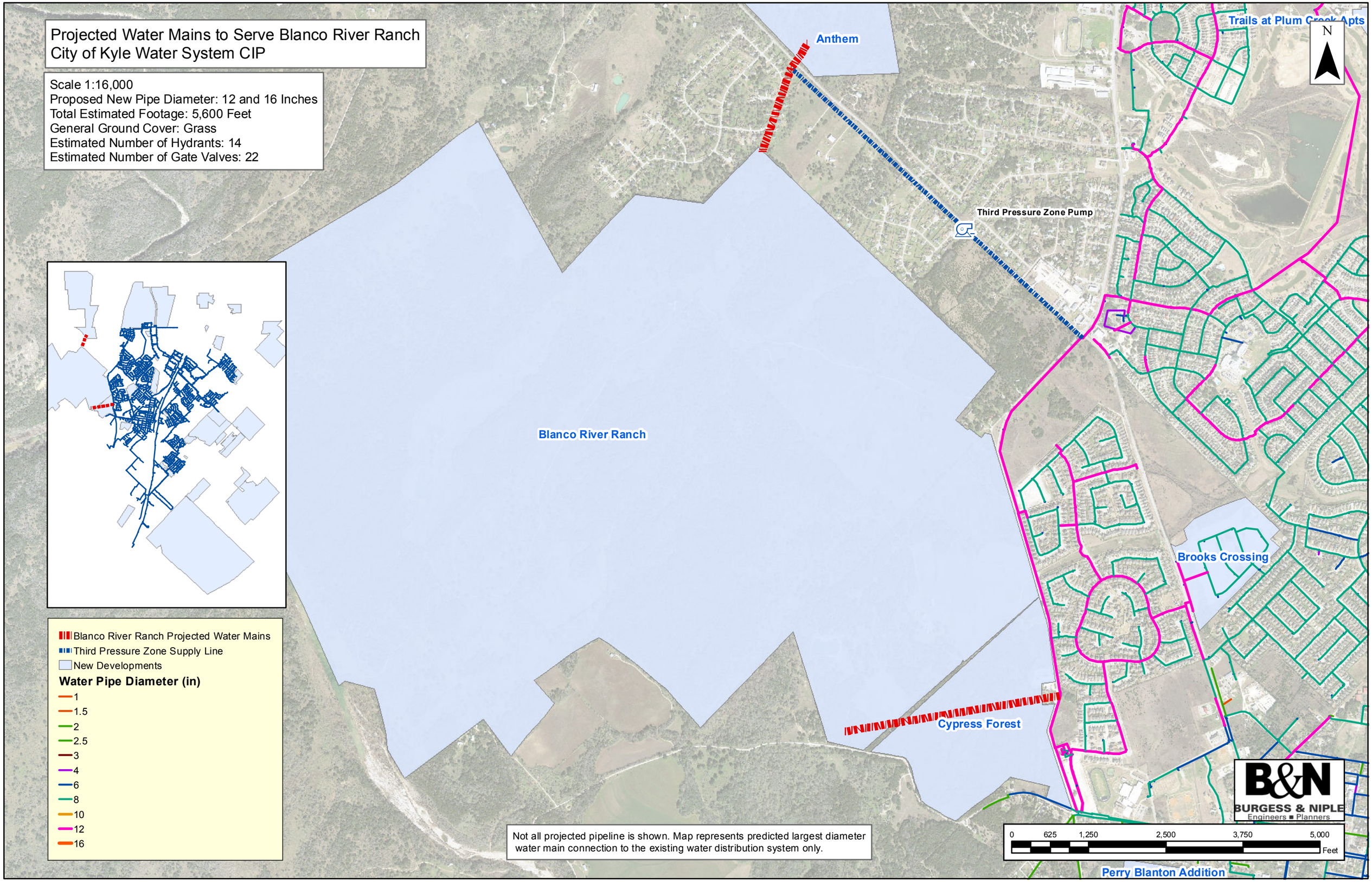
Projected Water Mains to Serve Aztec
City of Kyle Water System CIP

Scale 1:8,000
Proposed New Pipe Diameter: 12 Inches
Total Estimated Footage: 1,600 Feet
General Ground Cover: Asphalt
Estimated Number of Hydrants: 4
Estimated Number of Gate Valves: 6



Projected Water Mains to Serve Blanco River Ranch
City of Kyle Water System CIP

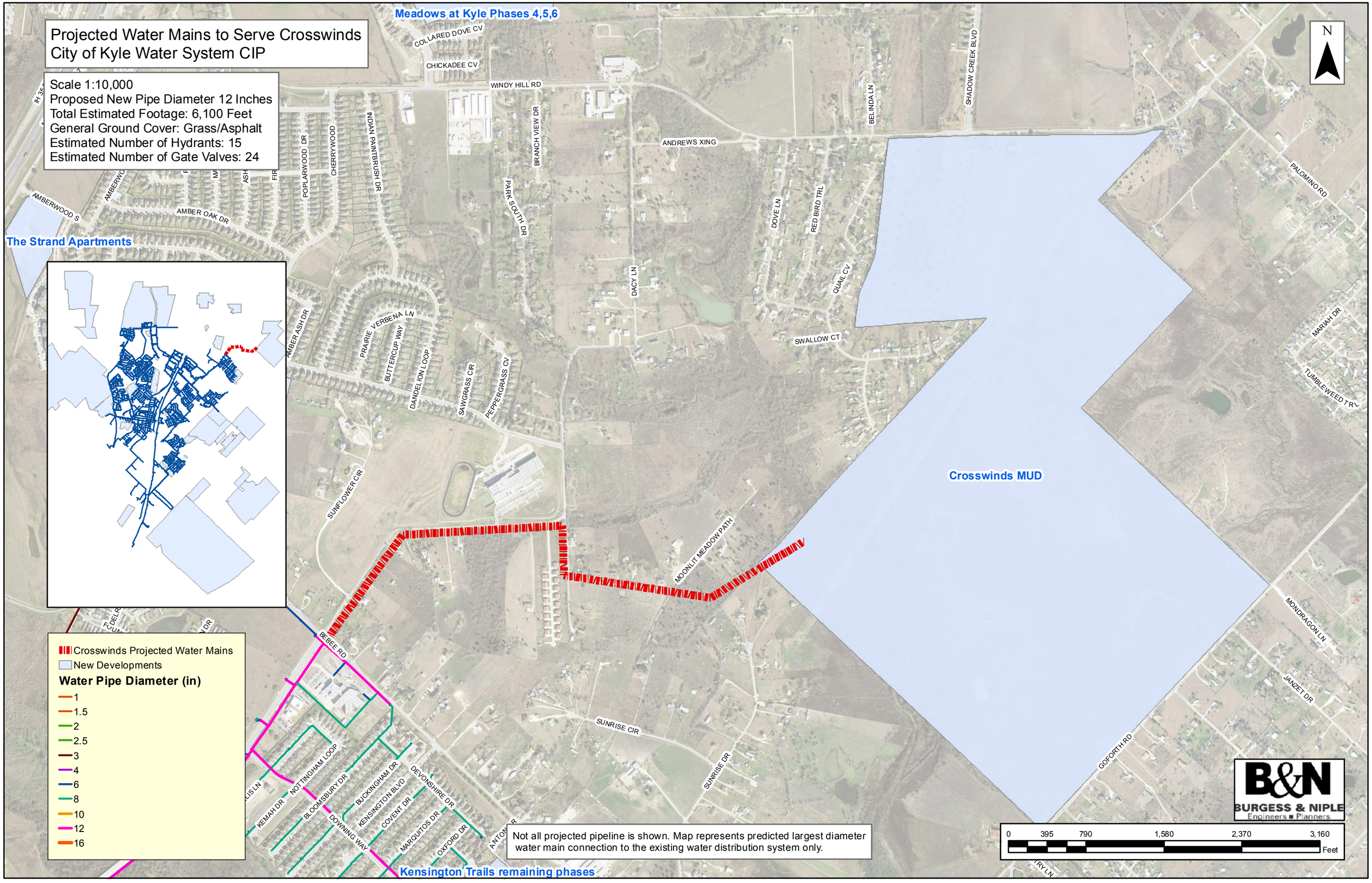
Scale 1:16,000
Proposed New Pipe Diameter: 12 and 16 Inches
Total Estimated Footage: 5,600 Feet
General Ground Cover: Grass
Estimated Number of Hydrants: 14
Estimated Number of Gate Valves: 22



Not all projected pipeline is shown. Map represents predicted largest diameter water main connection to the existing water distribution system only.

Projected Water Mains to Serve Crosswinds
City of Kyle Water System CIP

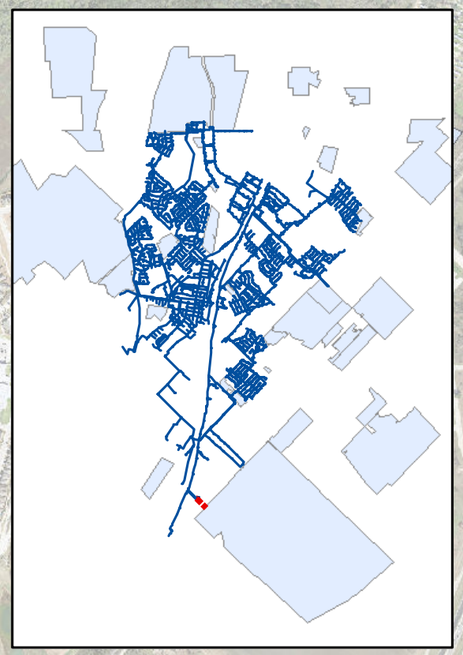
Scale 1:10,000
Proposed New Pipe Diameter 12 Inches
Total Estimated Footage: 6,100 Feet
General Ground Cover: Grass/Asphalt
Estimated Number of Hydrants: 15
Estimated Number of Gate Valves: 24



Not all projected pipeline is shown. Map represents predicted largest diameter water main connection to the existing water distribution system only.

Projected Water Mains to Serve La Salle
City of Kyle Water System CIP

Scale 1:16,000
Proposed New Pipe Diameter: 12 Inches
Total Estimated Footage: 1,200 Feet
General Ground Cover: Grass
Estimated Number of Hydrants: 3
Estimated Number of Gate Valves: 5



Post Oak Phase 5,6 & 7

Cool Springs

Pecan Woo

Pecan Woods

La Salle MUD

N

LaSalle Projected Water Mains
New Developments

Water Pipe Diameter (in)

- 1
- 1.5
- 2
- 2.5
- 3
- 4
- 6
- 8
- 10
- 12
- 16

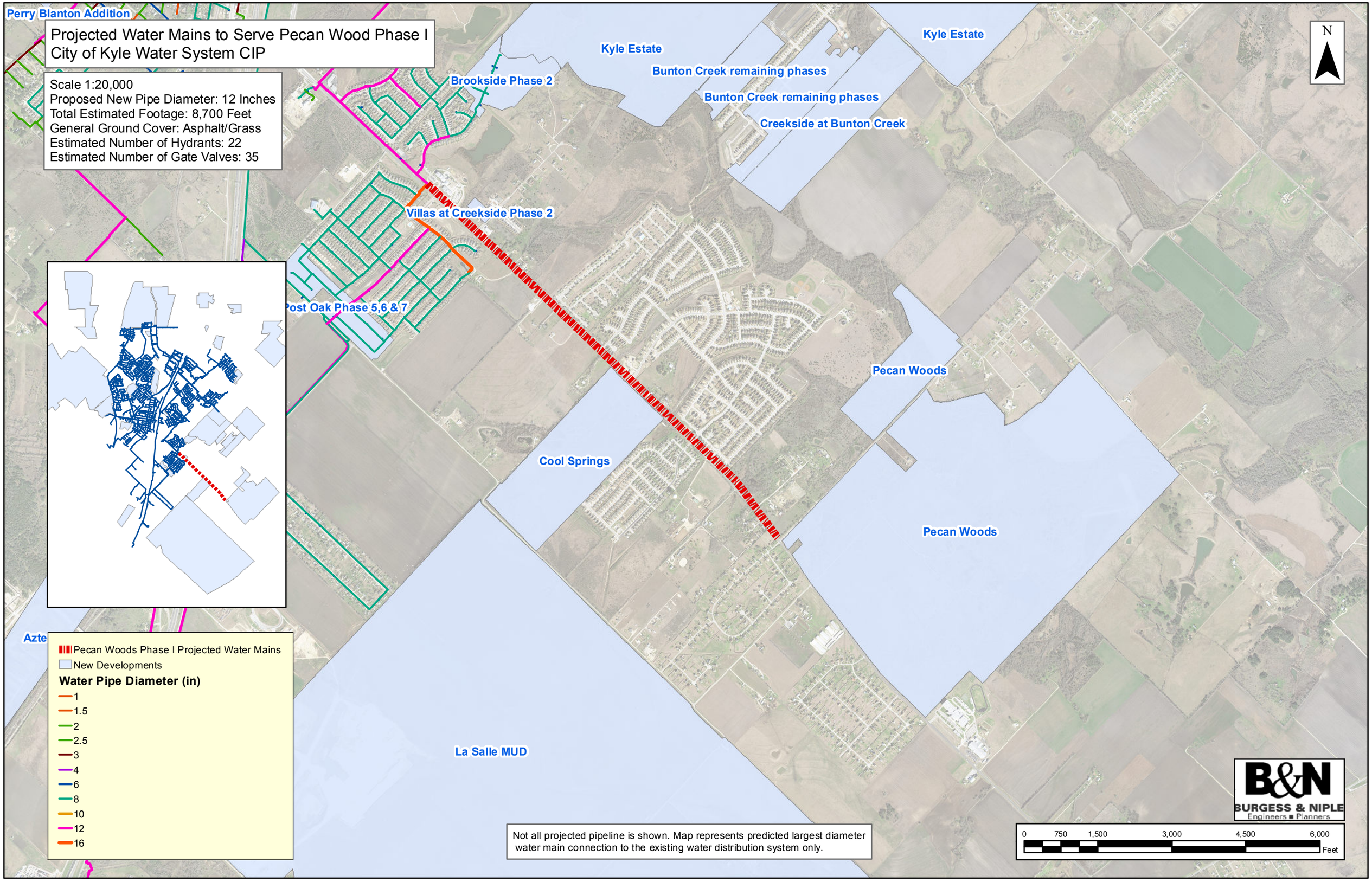
Not all projected pipeline is shown. Map represents predicted largest diameter water main connection to the existing water distribution system only.

B&N
BURGESS & NIPLE
Engineers ■ Planners

0 625 1,250 2,500 3,750 5,000 Feet

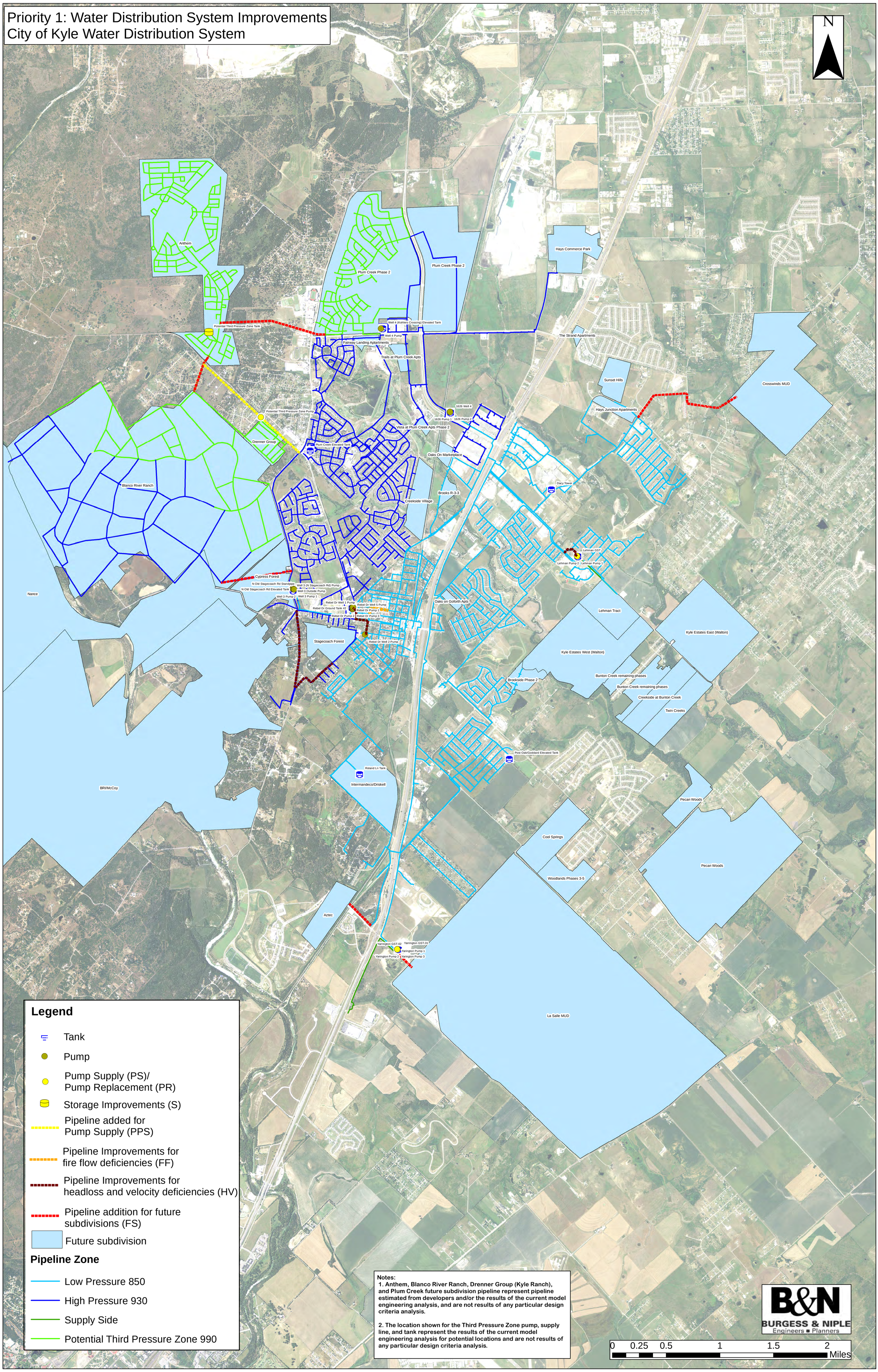
Projected Water Mains to Serve Pecan Wood Phase I
City of Kyle Water System CIP

Scale 1:20,000
Proposed New Pipe Diameter: 12 Inches
Total Estimated Footage: 8,700 Feet
General Ground Cover: Asphalt/Grass
Estimated Number of Hydrants: 22
Estimated Number of Gate Valves: 35

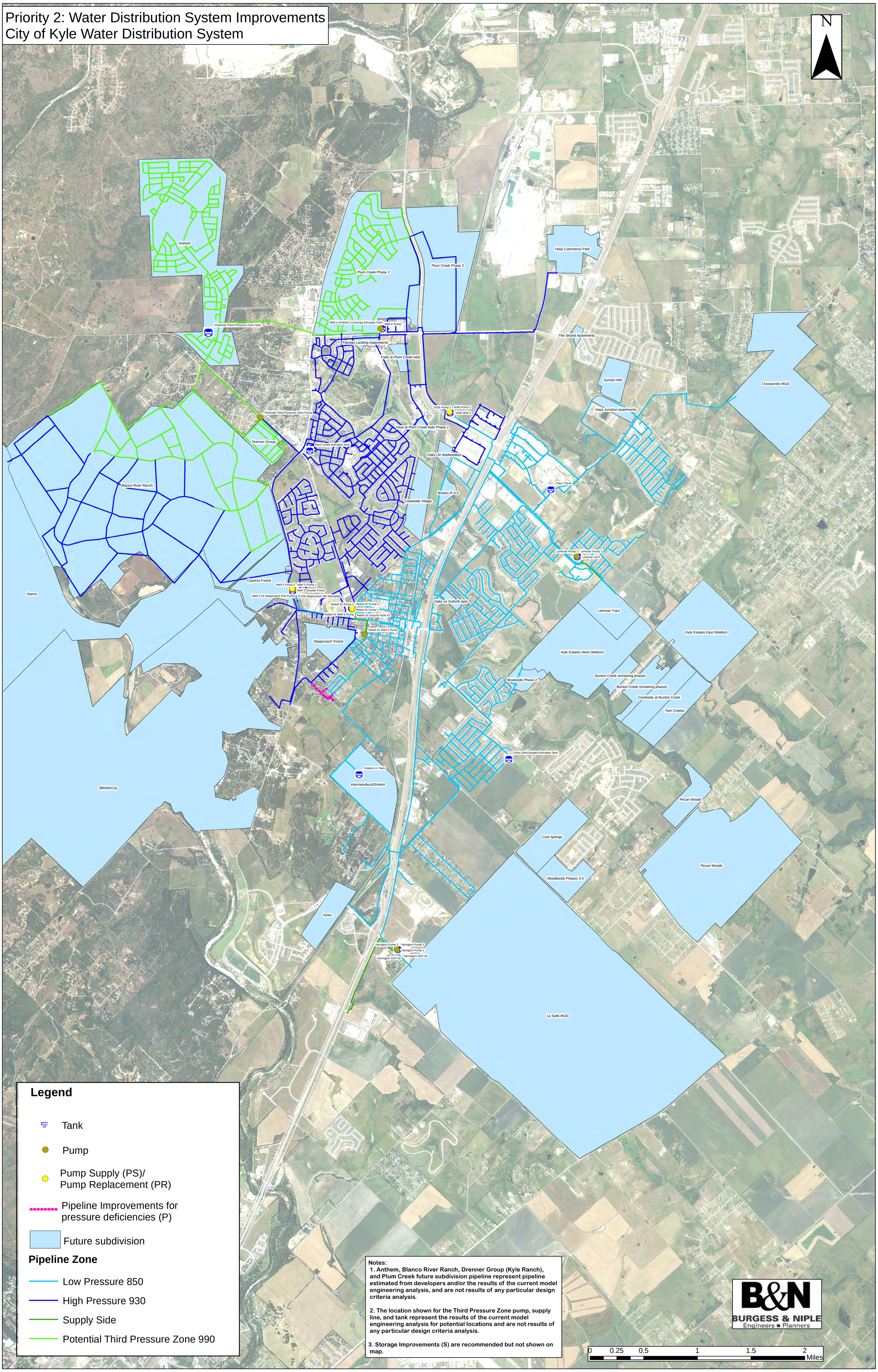


Not all projected pipeline is shown. Map represents predicted largest diameter water main connection to the existing water distribution system only.

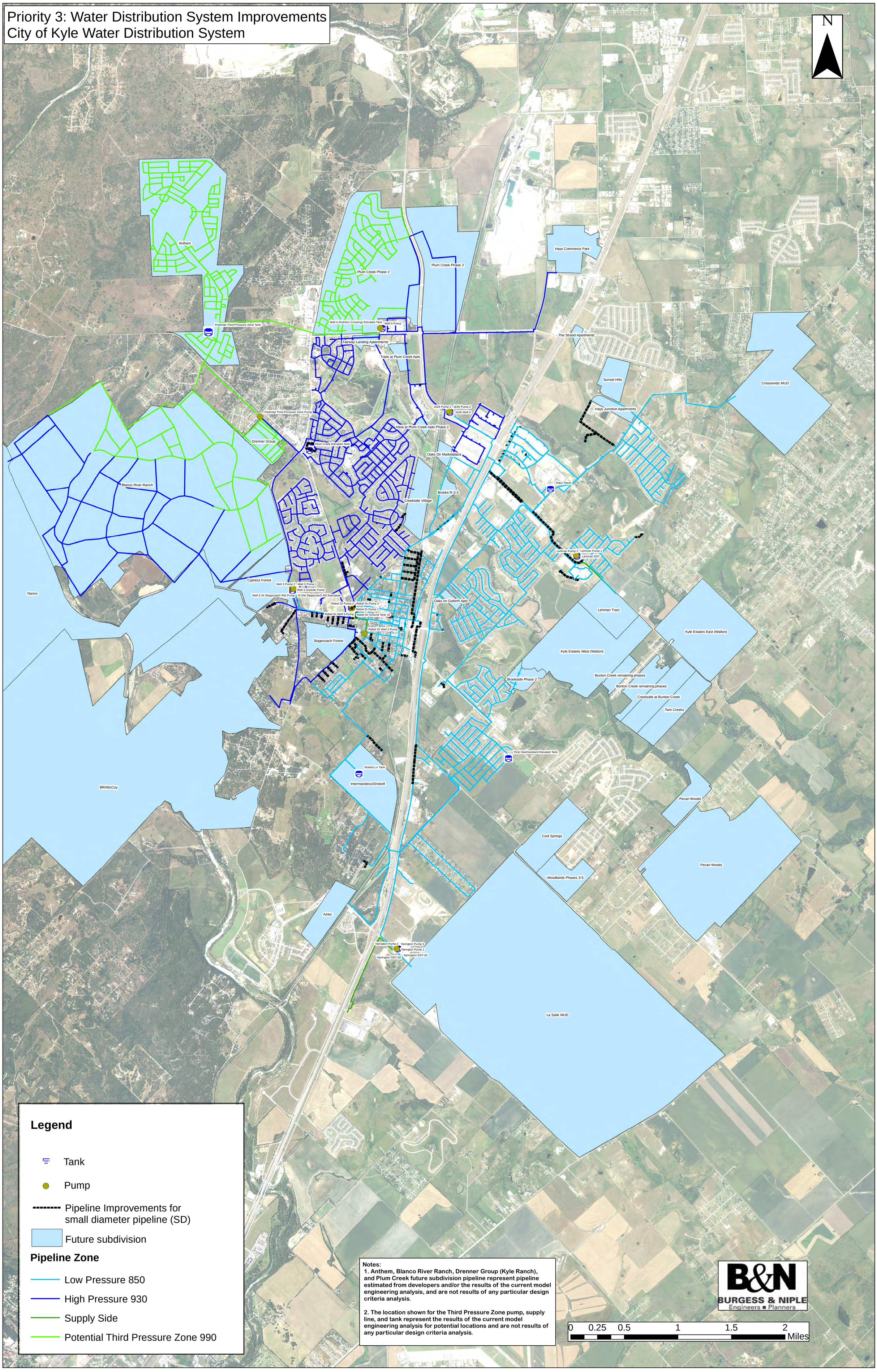
Priority 1: Water Distribution System Improvements
City of Kyle Water Distribution System



Priority 2: Water Distribution System Improvements
City of Kyle Water Distribution System



Priority 3: Water Distribution System Improvements
City of Kyle Water Distribution System



Burgess & Niple, Inc.
Civil / Environmental Engineers and Planners
4029 Capital of Texas Hwy., Suite 220
Austin , Texas 78701
512.306.9266
www.burgessniple.com